Climate Forecasting Unit

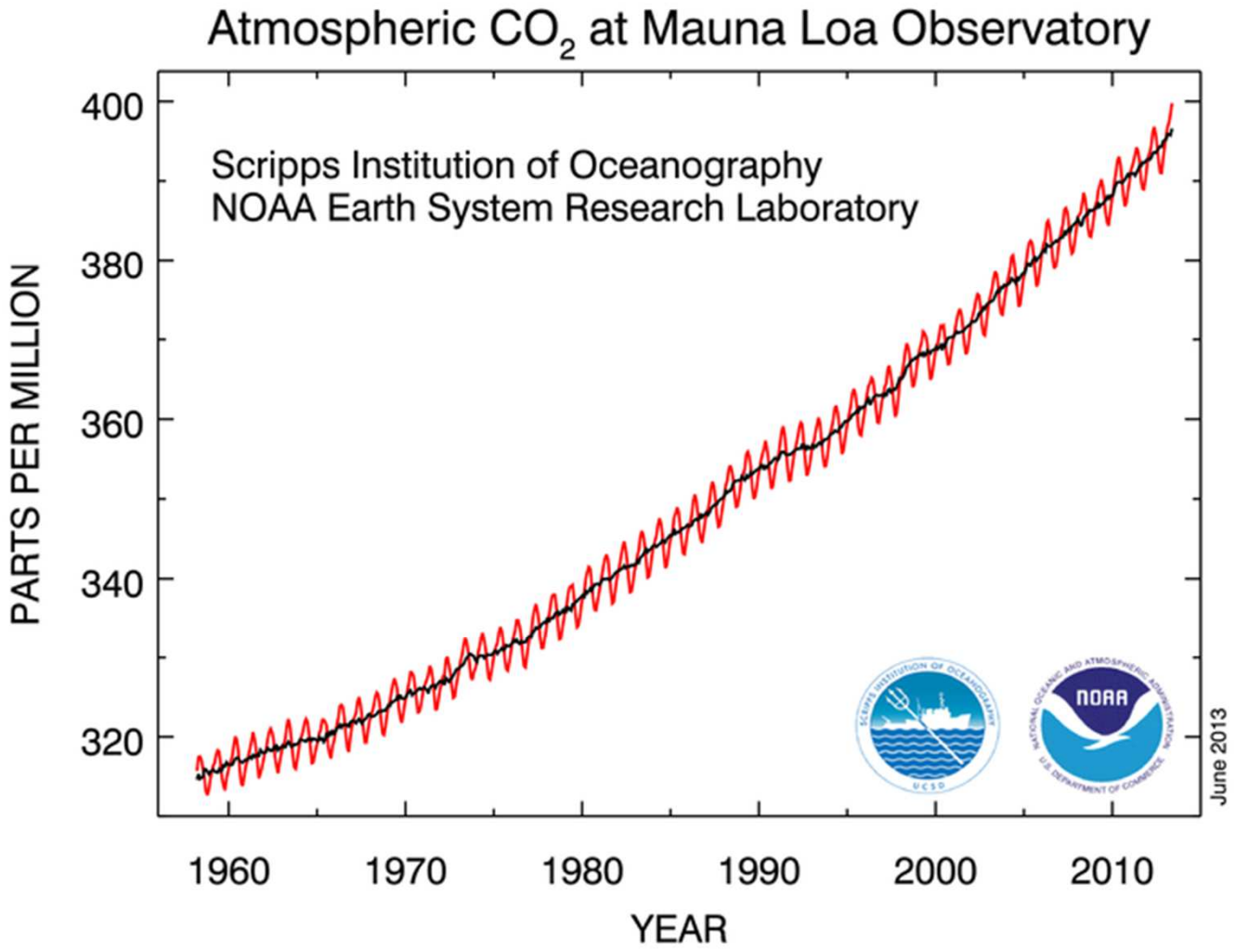
SPECS
Seasonal-to-decadal climate Prediction for the improvement of European Climate Services

METEO FRANCE

Quelles sont les causes du plateau en température moyenne globale de la dernière décennie?

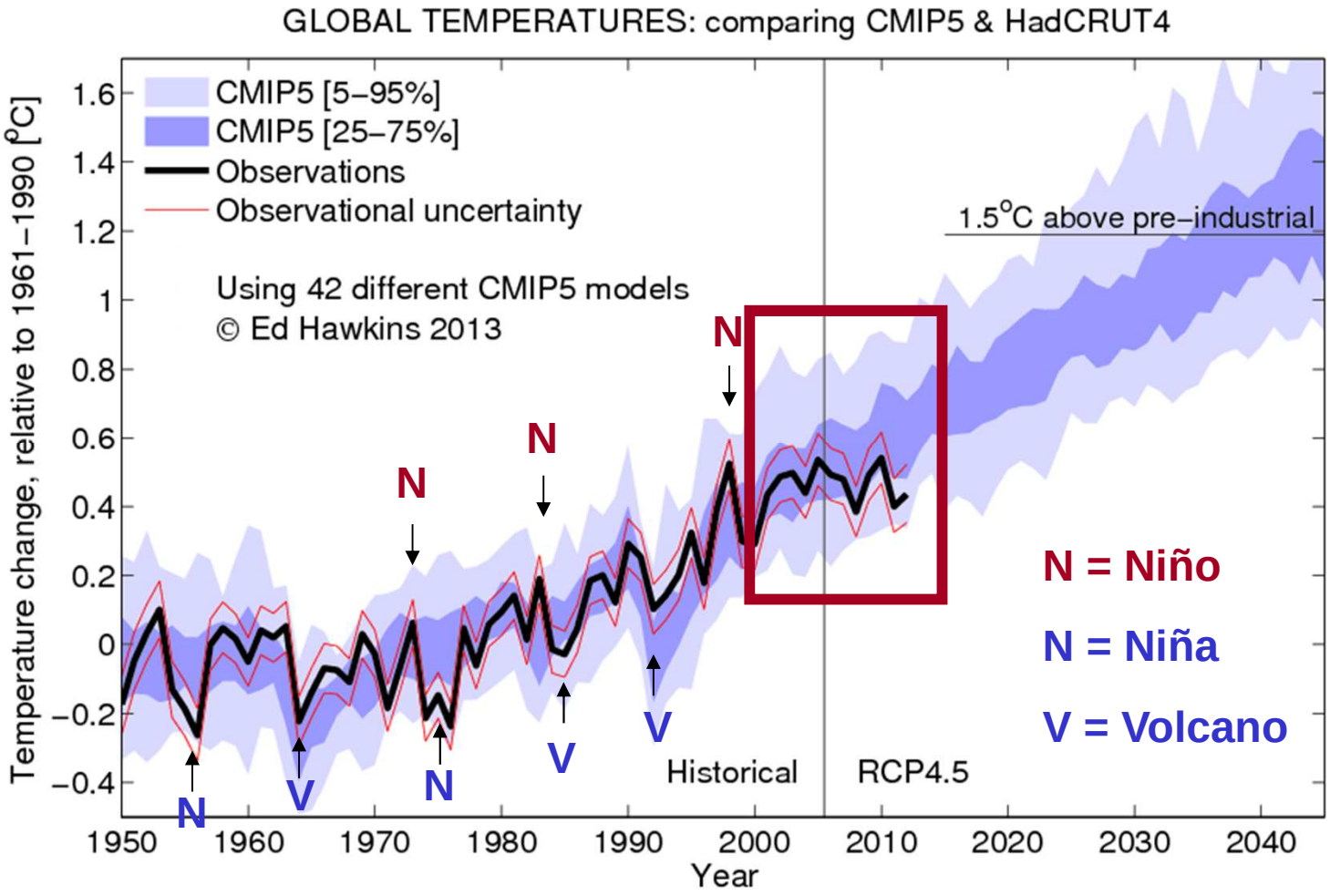
Virginie Guemas and Francisco J. Doblas-Reyes

Issue



A steady increase in greenhouse gas concentration

Issue



Ed Hawkins, Climate Lab Book, NCAS

Issue

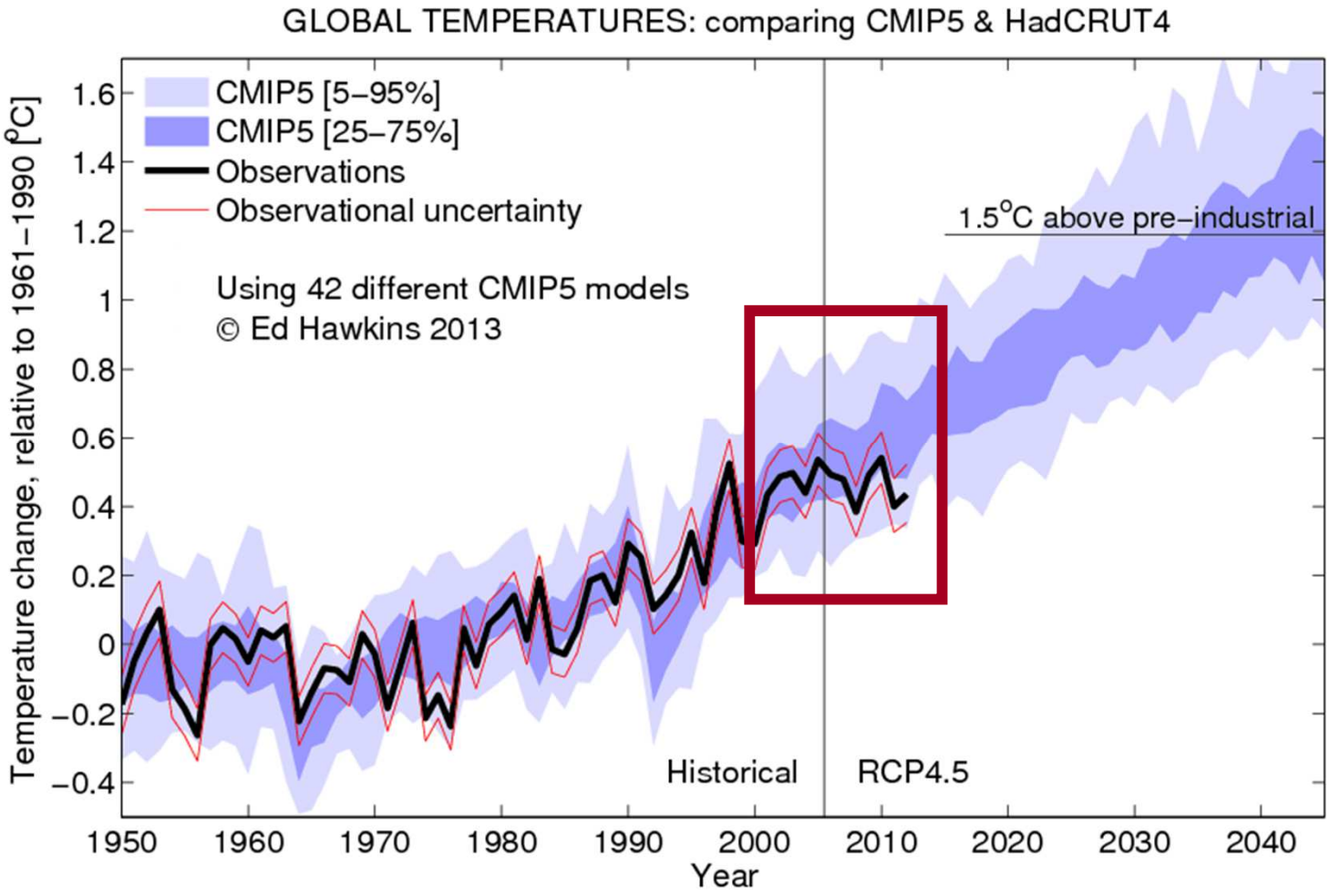
Is there an inconsistency between projected global mean temperature and observed one ?

Not within observational and model uncertainty

Why do we observed such temperature plateau instead of a temperature increase ?

The issue we focus on here

Issue



What are the mechanisms behind the temperature plateau ?

Hypotheses

A - a decrease in the stratospheric water vapour concentration (Solomon, 2010)

B - an increase in the background stratospheric aerosol concentration (Solomon, 2013; Fyfe et al, 2013)

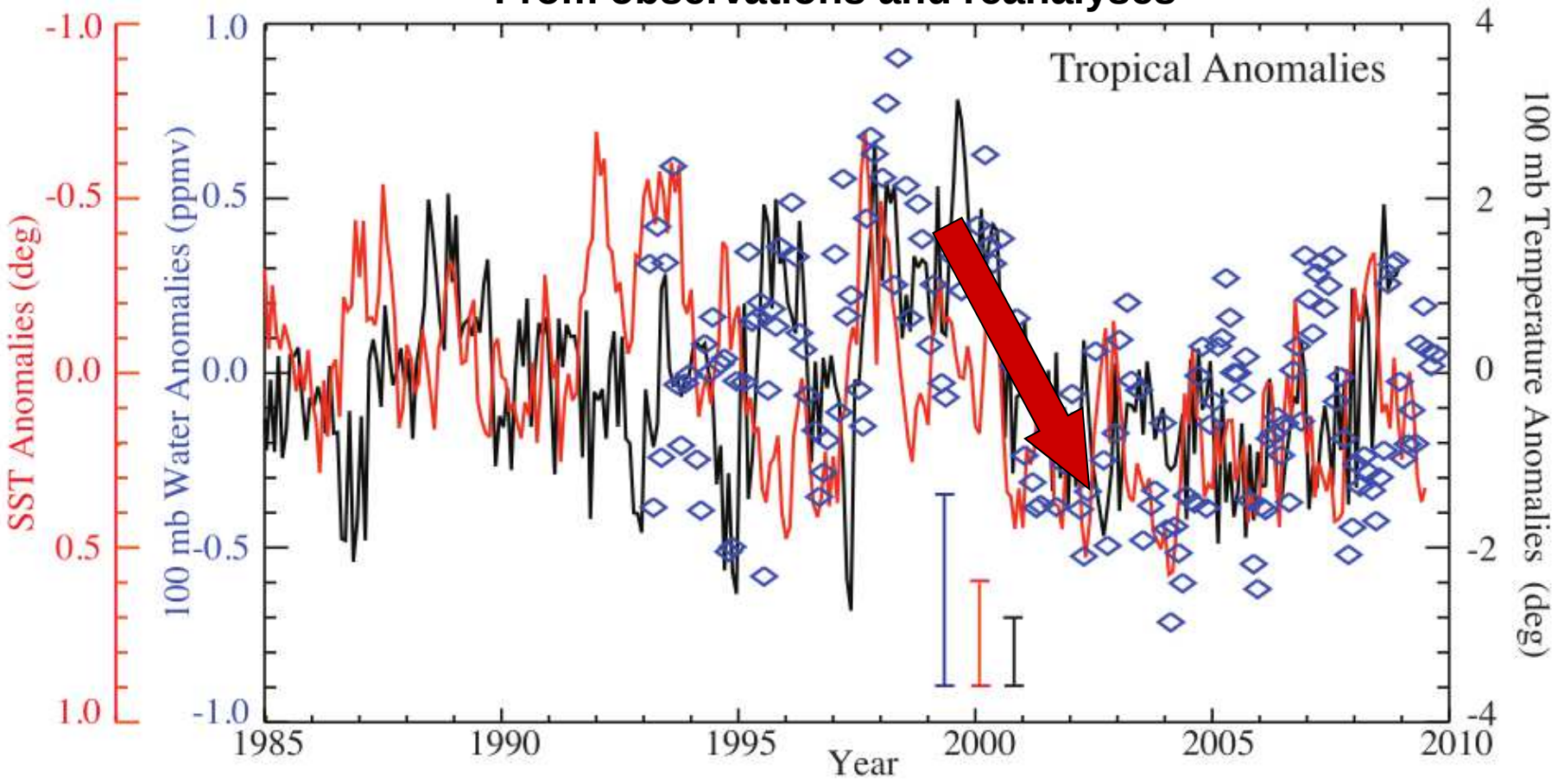
C - the deep and long solar minimum (Kaufmann et al., 2011; Hansen et al., 2011)

D - an increase in the tropospheric aerosol concentration (Kaufmann et al., 2011; Murphy, 2013)

E - an increase in the subsurface ocean heat uptake (Meehl et al, 2011; Guemas et al, 2013; England et al, 2014; Douville et al, 2015)

A : Stratospheric water vapour decrease

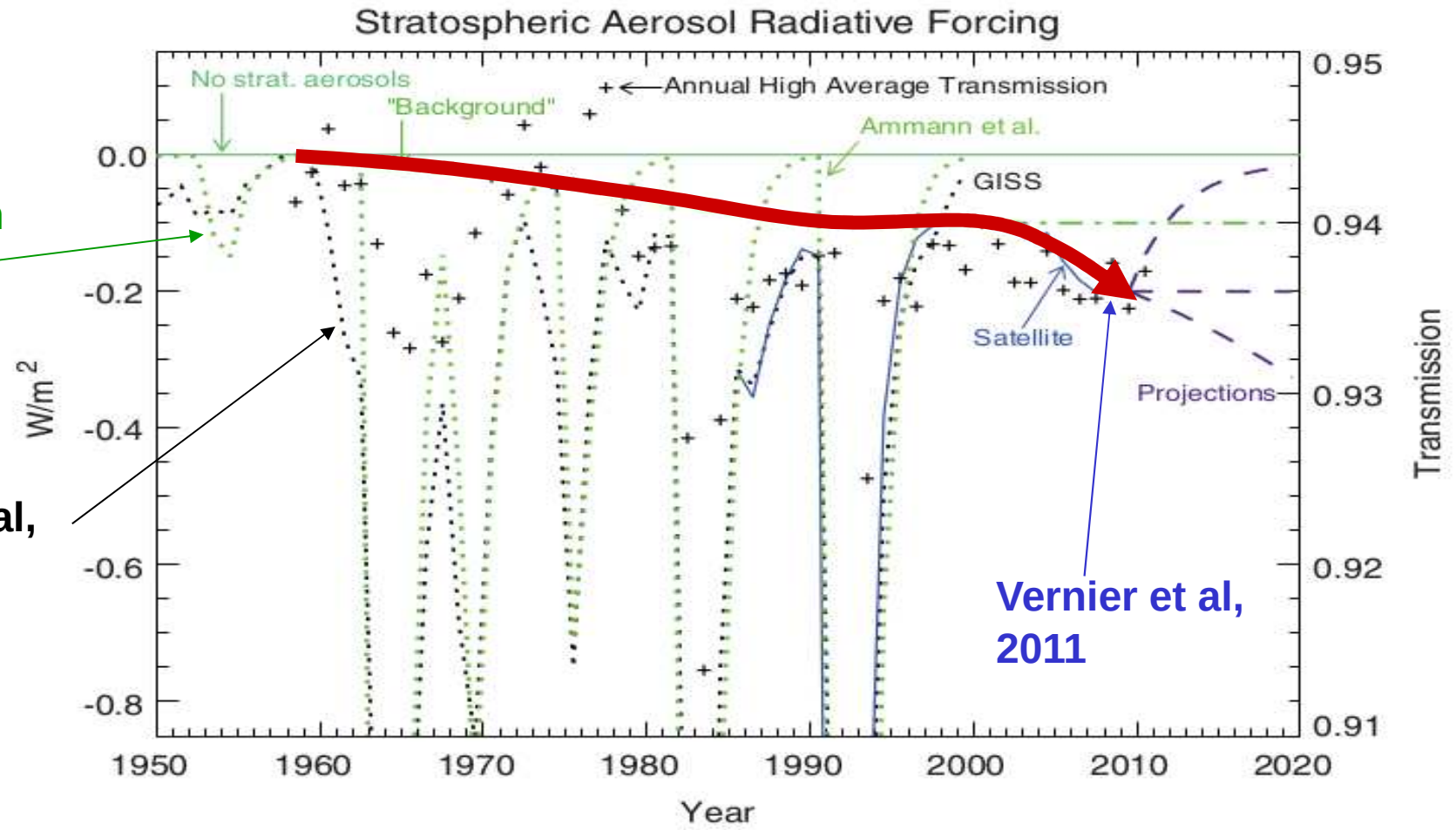
From observations and reanalyses



Water vapour changes 1996-2000 -> 2001-2005 explains about -0.1W.m^{-2} (net forcing : ~0.5W.m^{-2})

Solomon et al., 2010, Science

B : Stratospheric aerosol increase



Amman et al, 2003

Sato et al, 1993

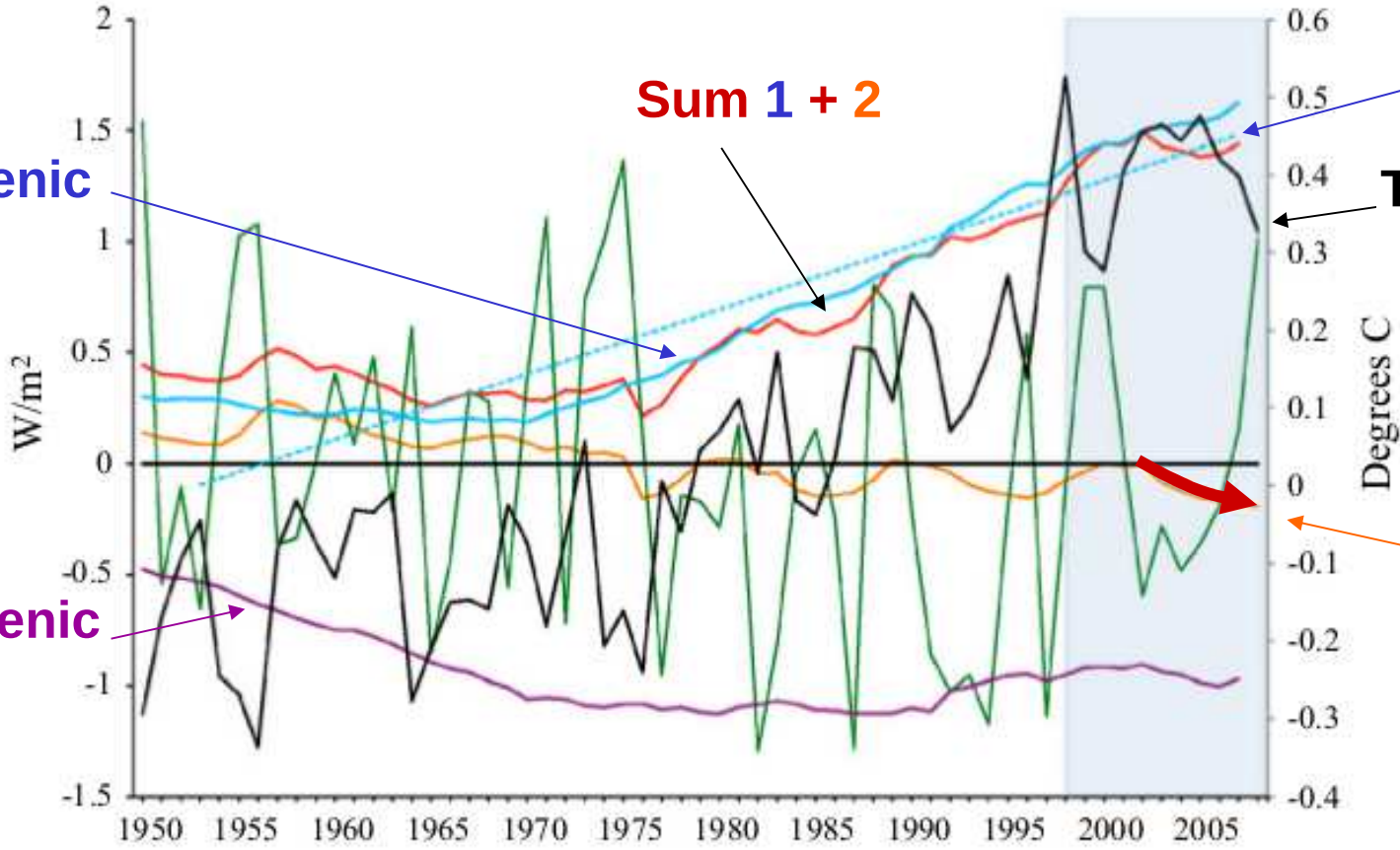
Vernier et al, 2011

Background stratospheric aerosol explains ≈ -0.1W.m^{-2}, which was not accounted for in CMIP5

Solomon et al., 2013, Science

C : Long solar minimum

From observations and reconstructions

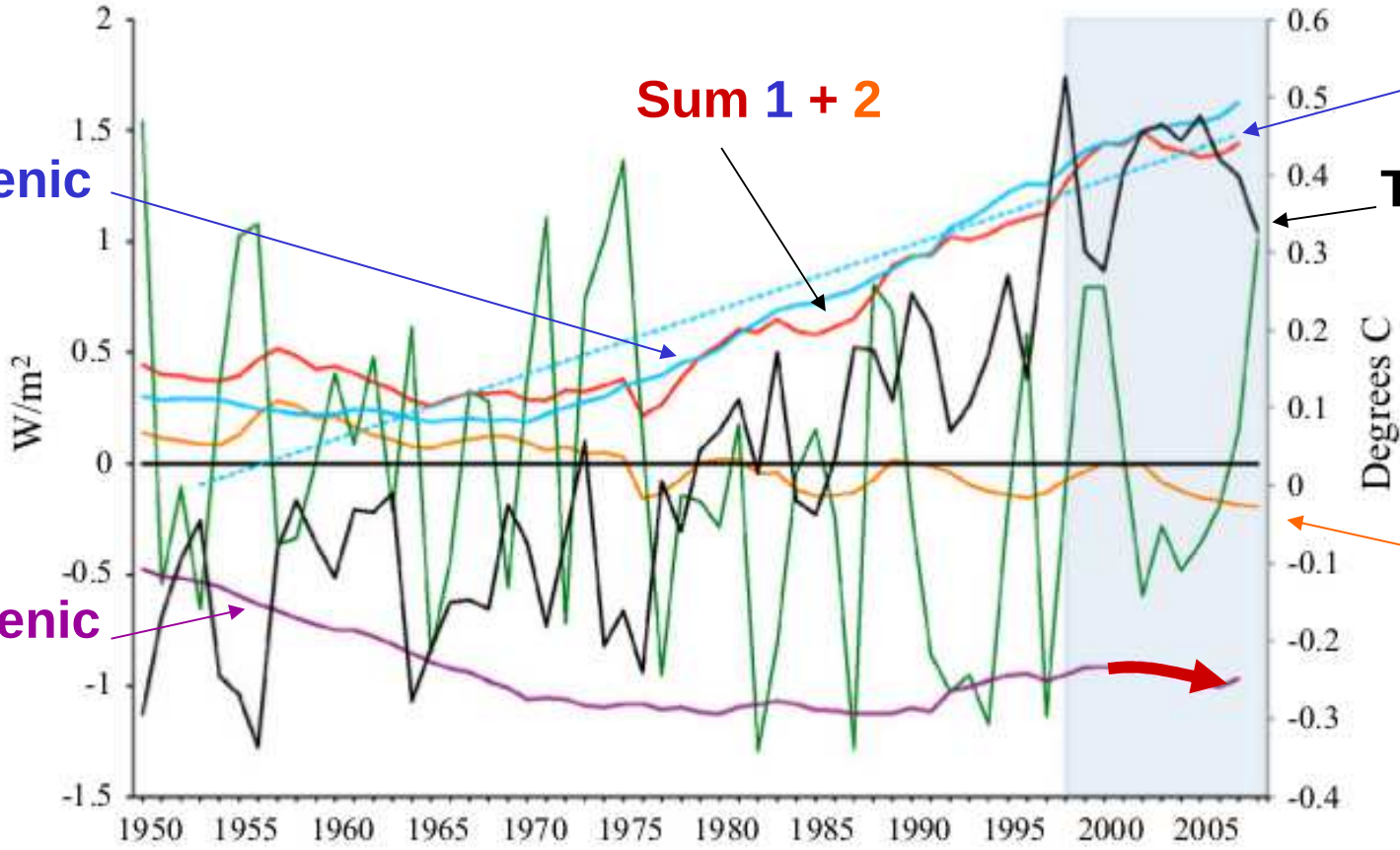


Solar cycle minimum explains about -0.2W.m-2, to be compared with ~0.5W.m-2 total forcing

Kaufmann et al., 2011, PNAS

D : Tropospheric aerosol increase

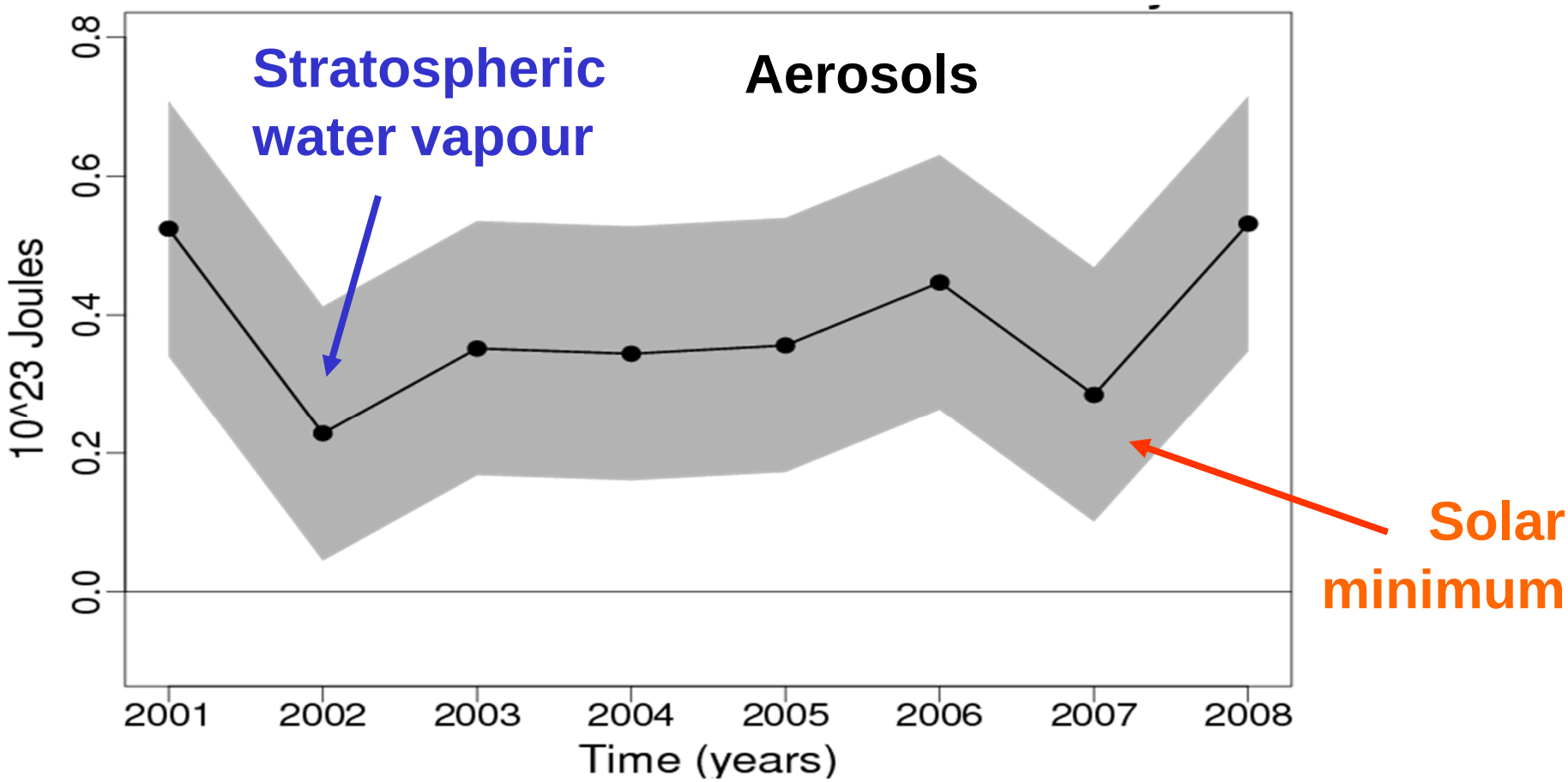
From observations and reconstructions



Tropospheric aerosol forcing explains about -0.06W.m^{-2} since 2002 (net forcing : ~0.5W.m-2)

Kaufmann et al., 2011, PNAS

Observed Top-Of-Atmosphere net input energy



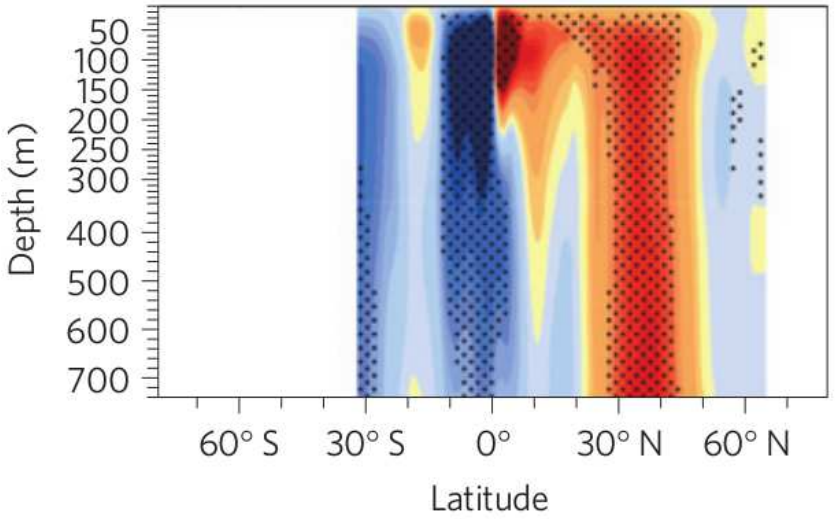
CERES TOA input energy still positive during the last decade, why does not the surface warm up?

Loeb et al., 2009, J. Climate

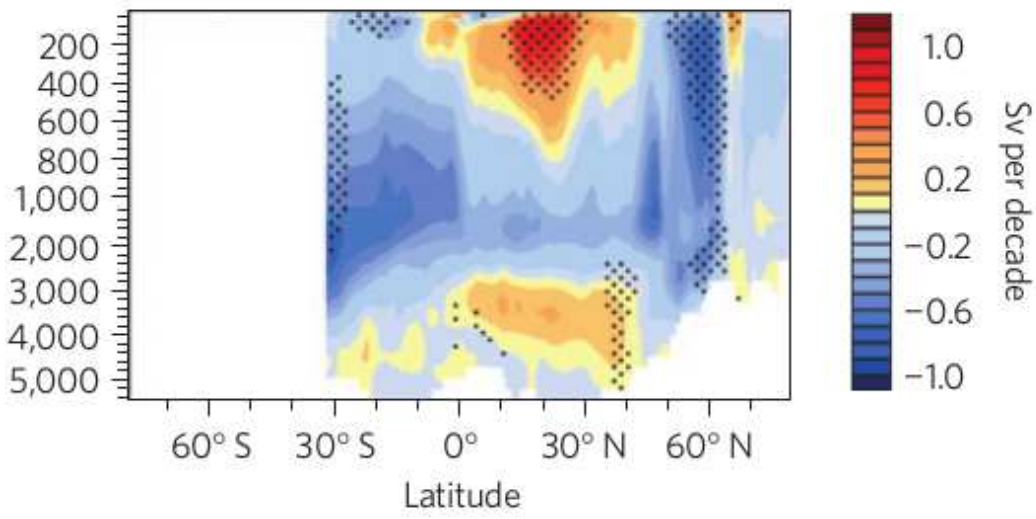
E : Increased ocean heat uptake

Composites of meridional overturning streamfunction anomalies during decades of surface temperature cooling in CCSM4

Pacific



Atlantic



Strengthening of the subtropical cells

Weakening of the deep convection

Increased subsurface ocean heat uptake might compensate for TOA absorption during hiatus periods

Meehl et al, 2011, Nature Climate Change

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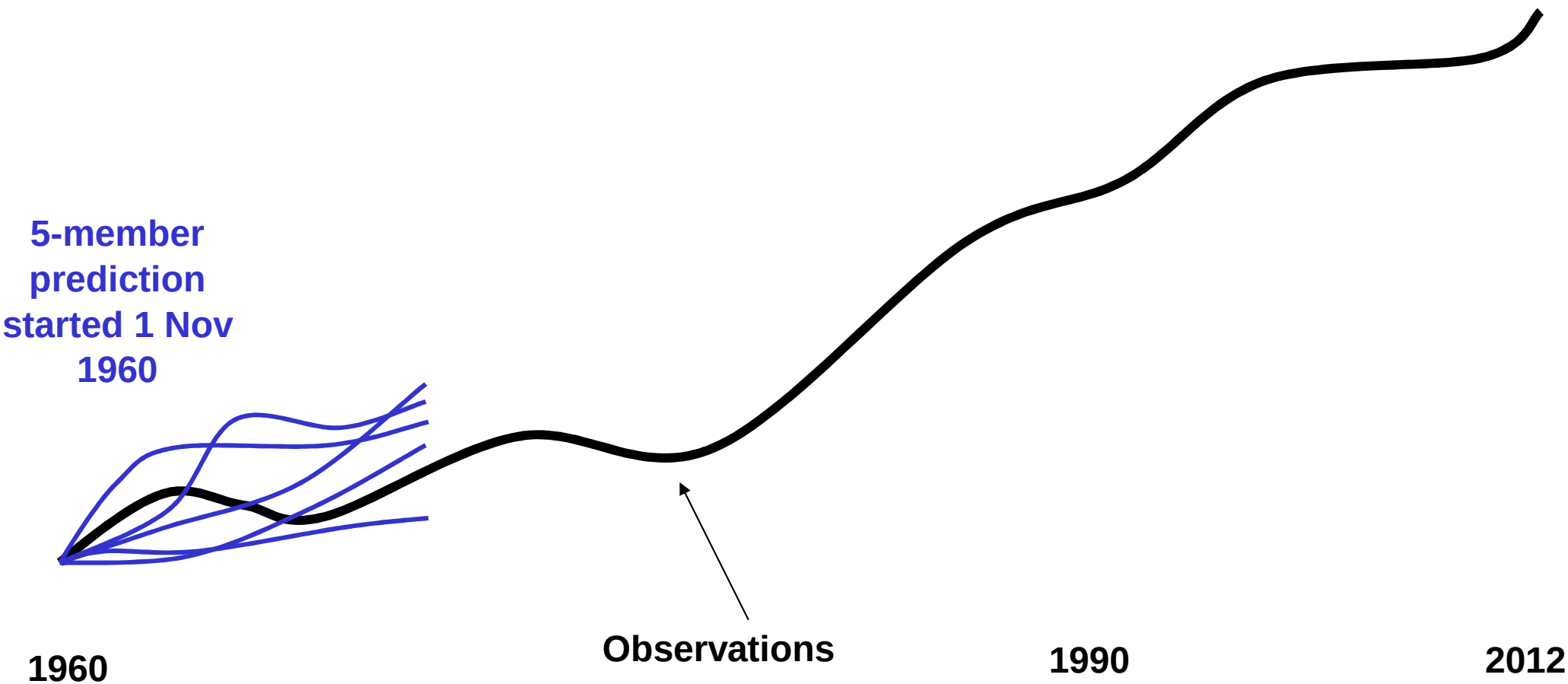
E : Increased ocean heat uptake

Can we use climate predictions to investigate the mechanisms behing the XXIst century hiatus?

Guemas V. , Doblas-Reyes F. J., Andreu-Burillo I., Asif M., 2013, Retrospective prediction of the global warming slowdown in the past decade. *Nature Climate Change*, doi : 10.1038/nclimate1863.

Methodology

Experimental setup



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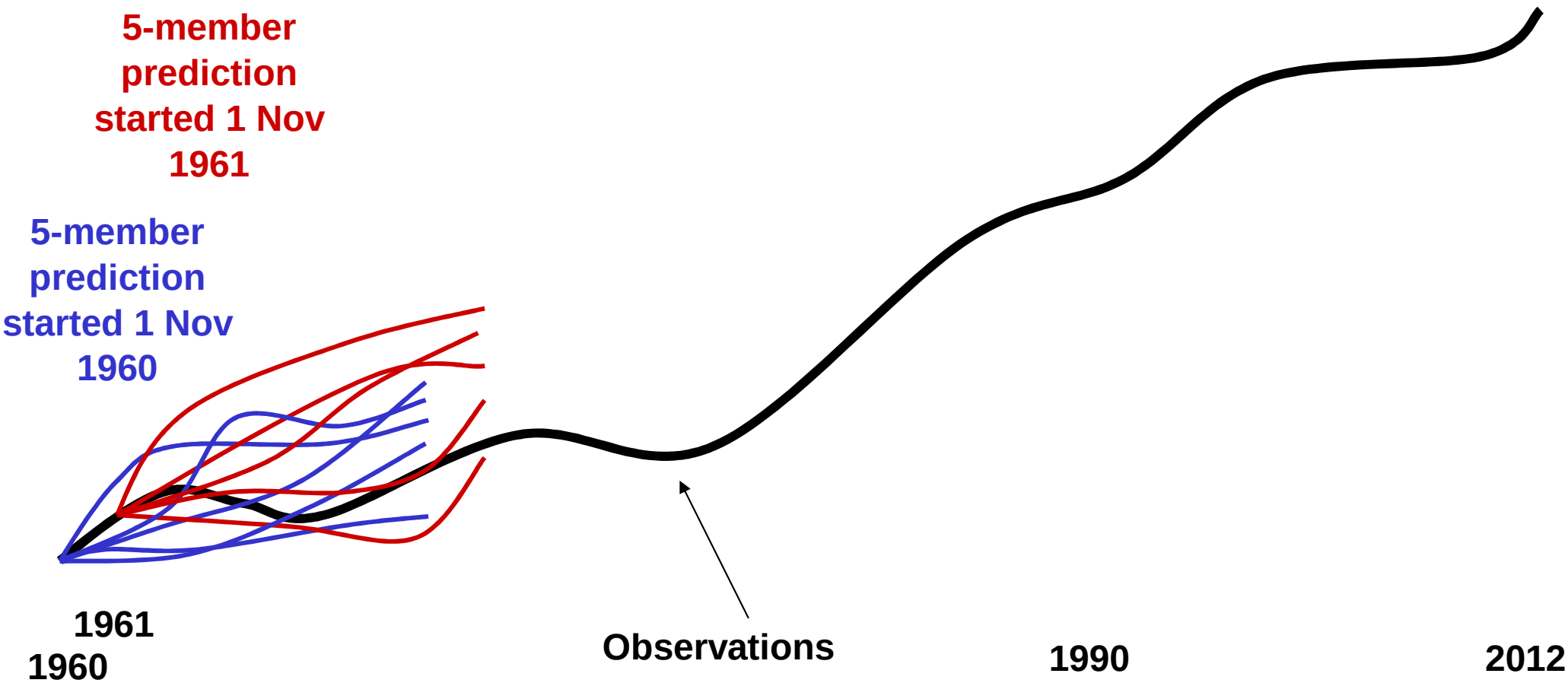

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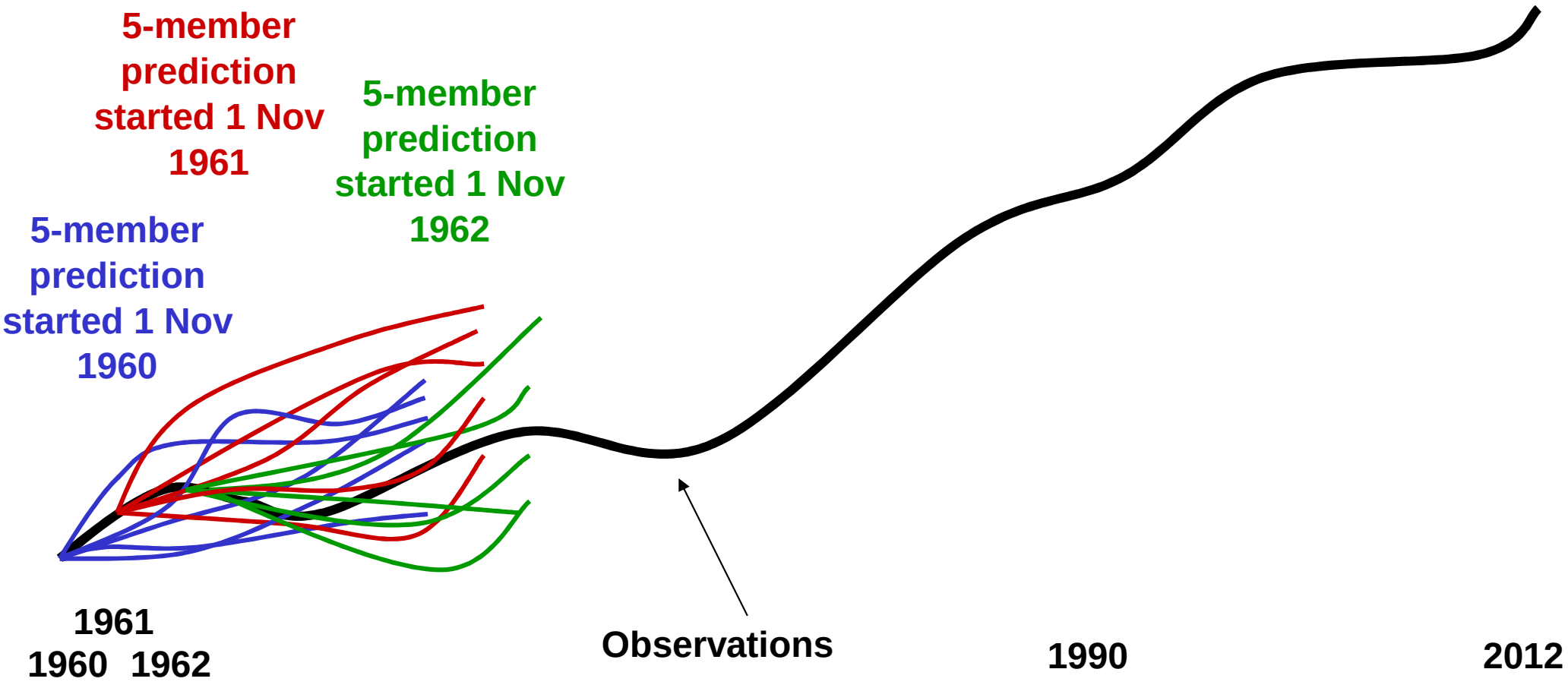

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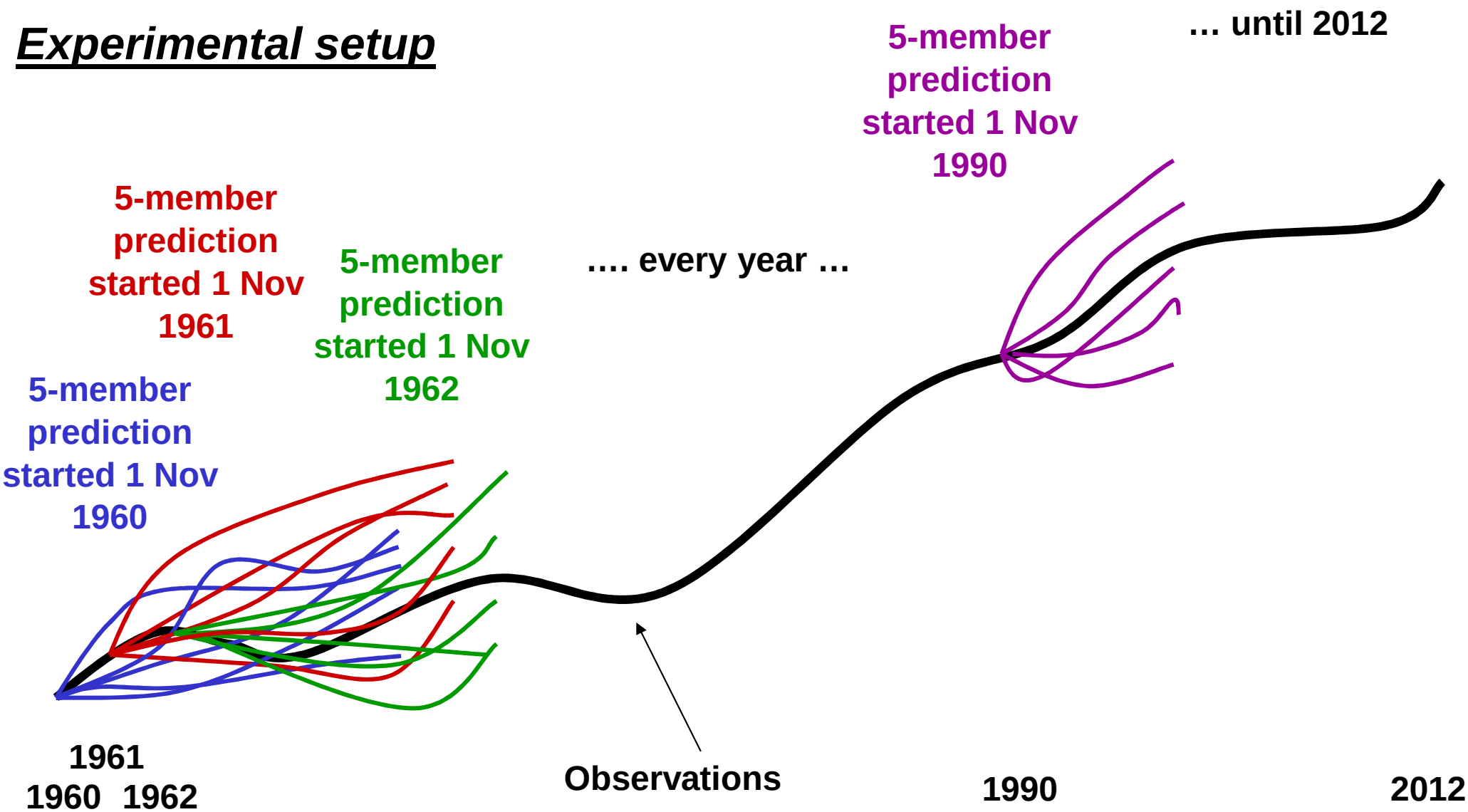

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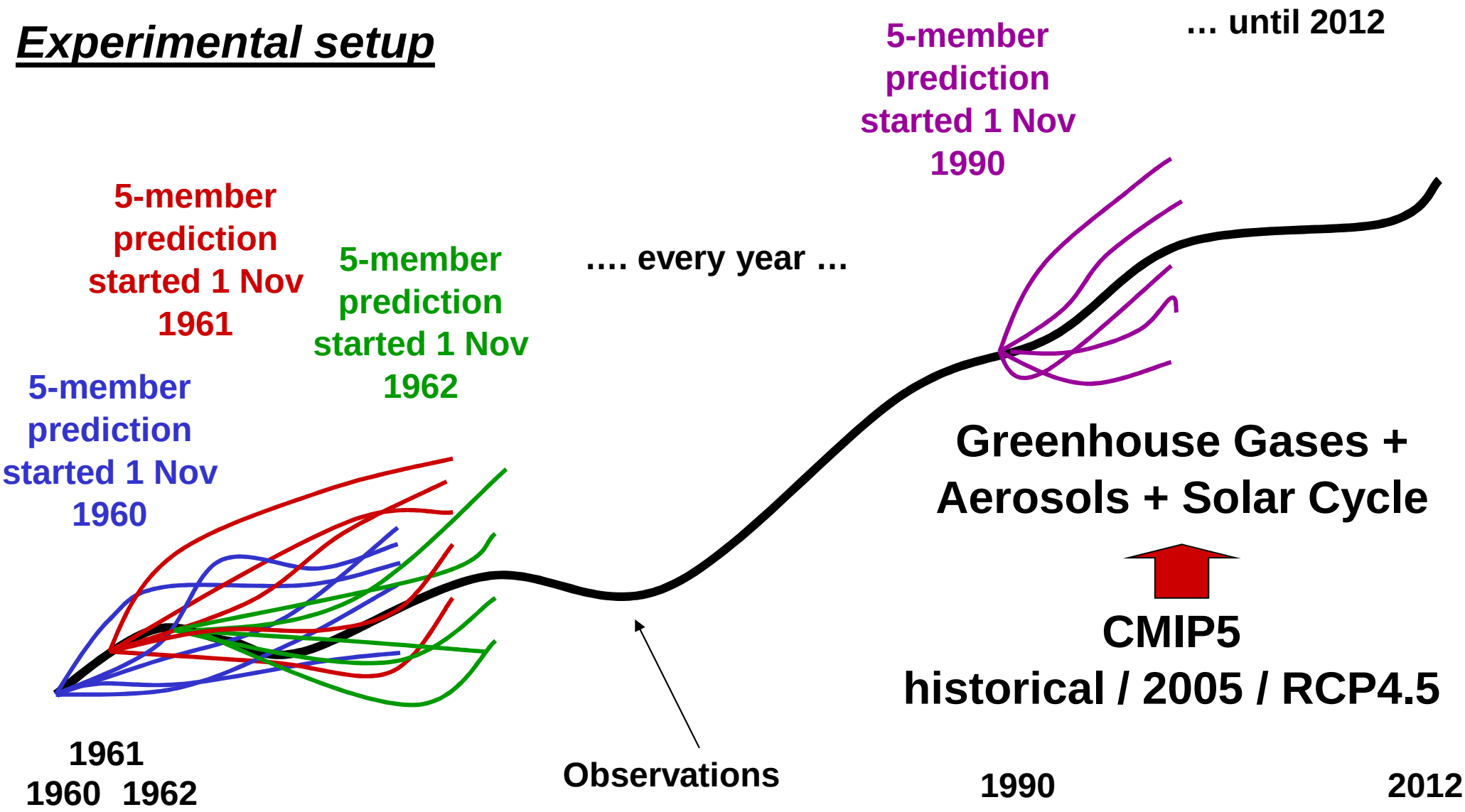
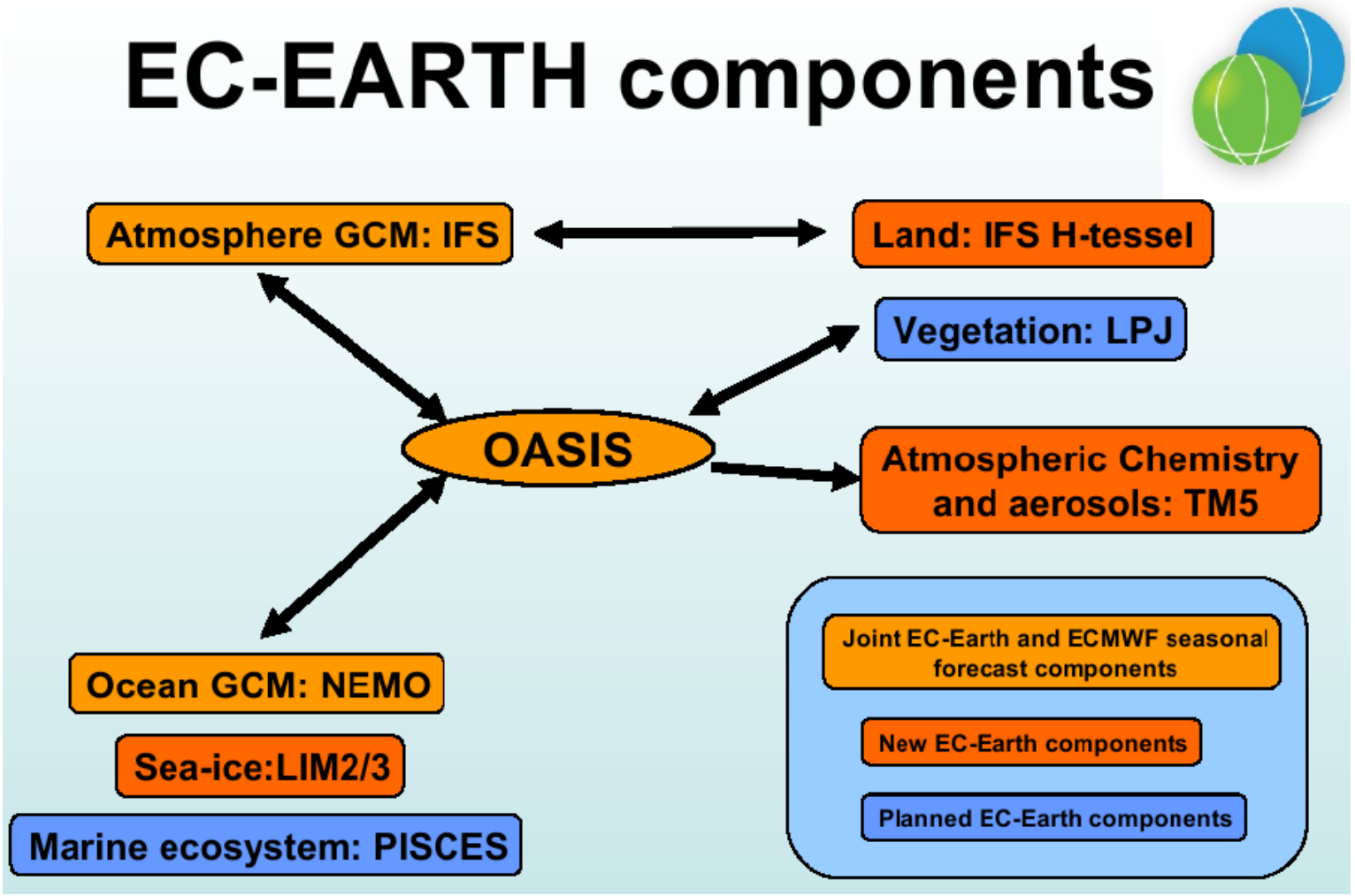


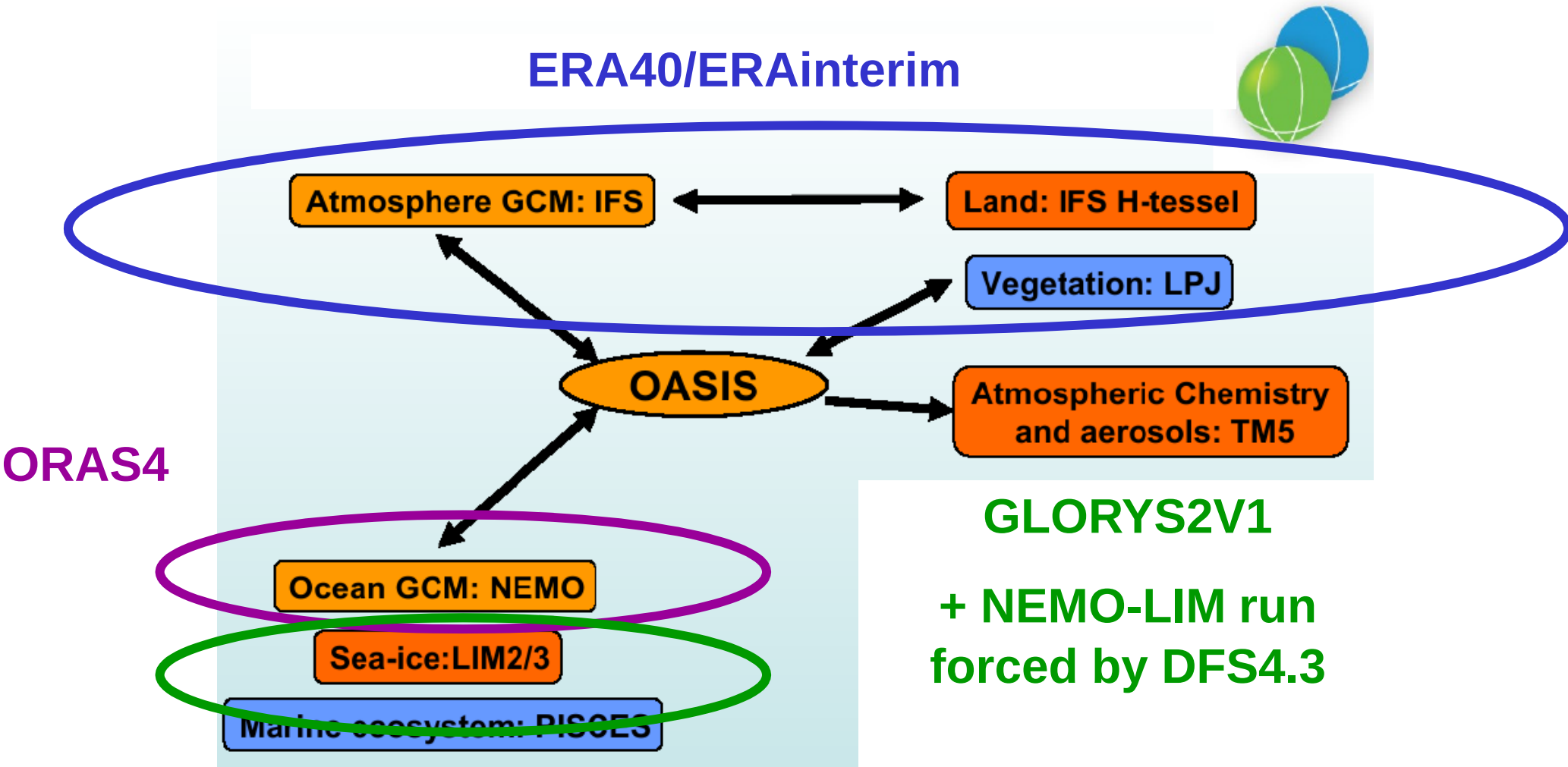
Methodology

Model



Methodology

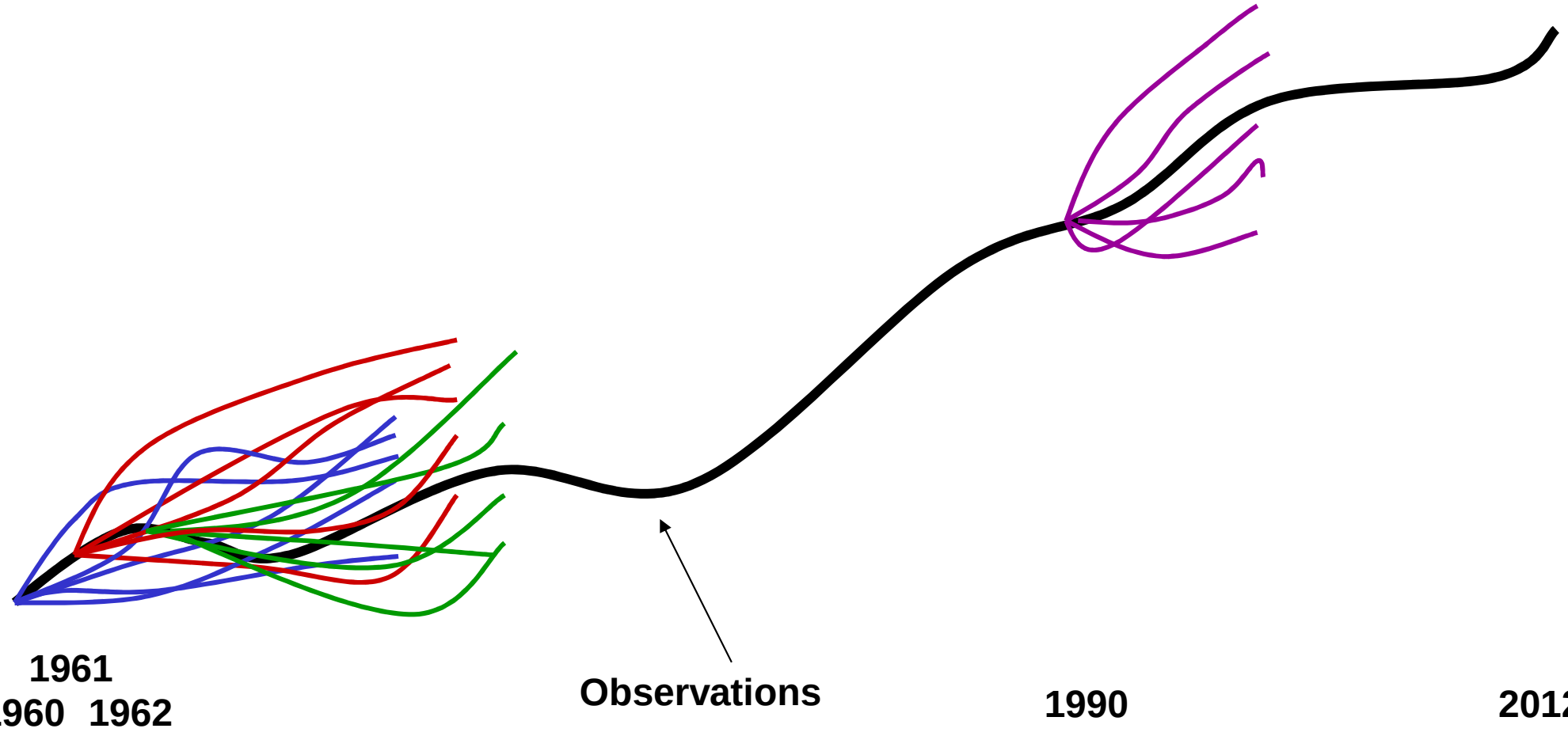
Full field Initialisation



Methodology

Analyses:

Example : Focus on 3rd forecast year



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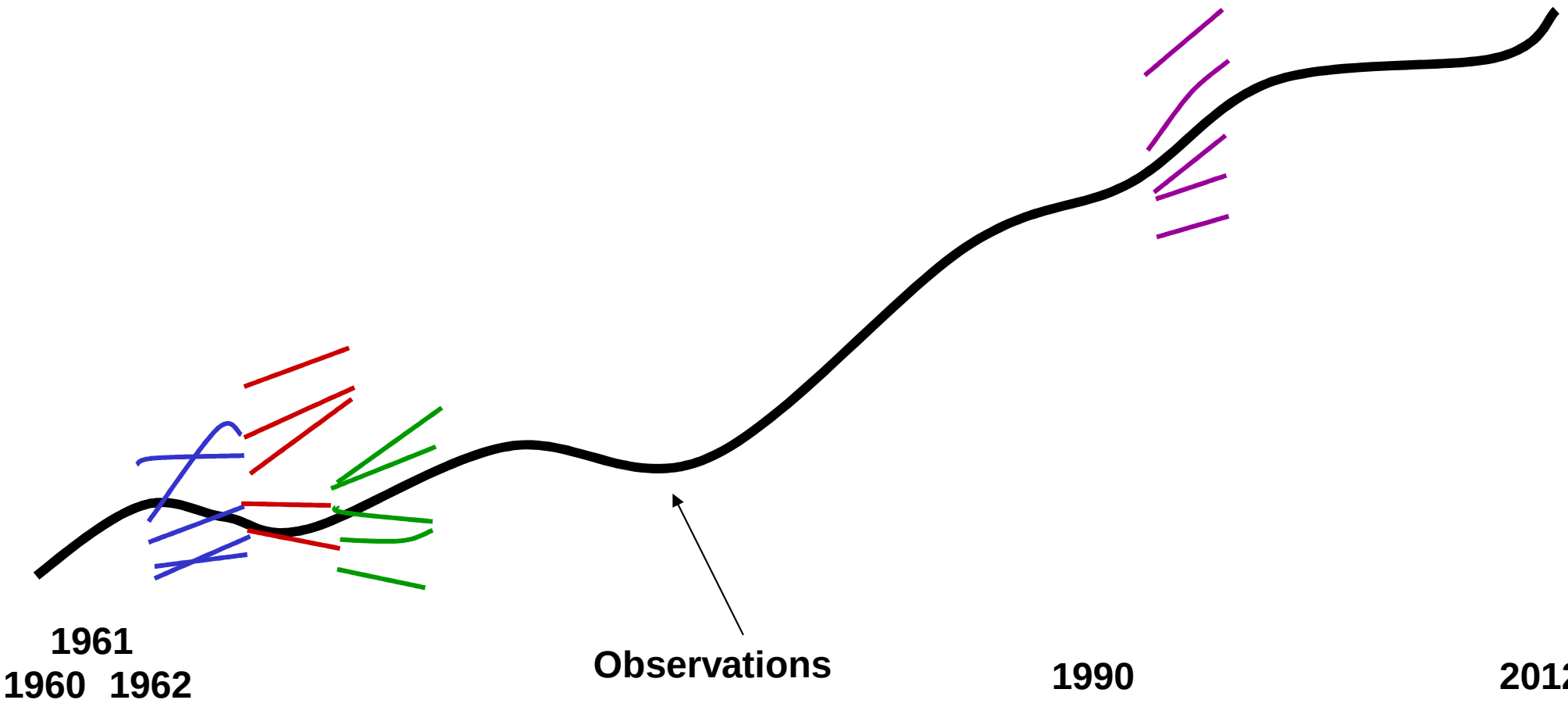

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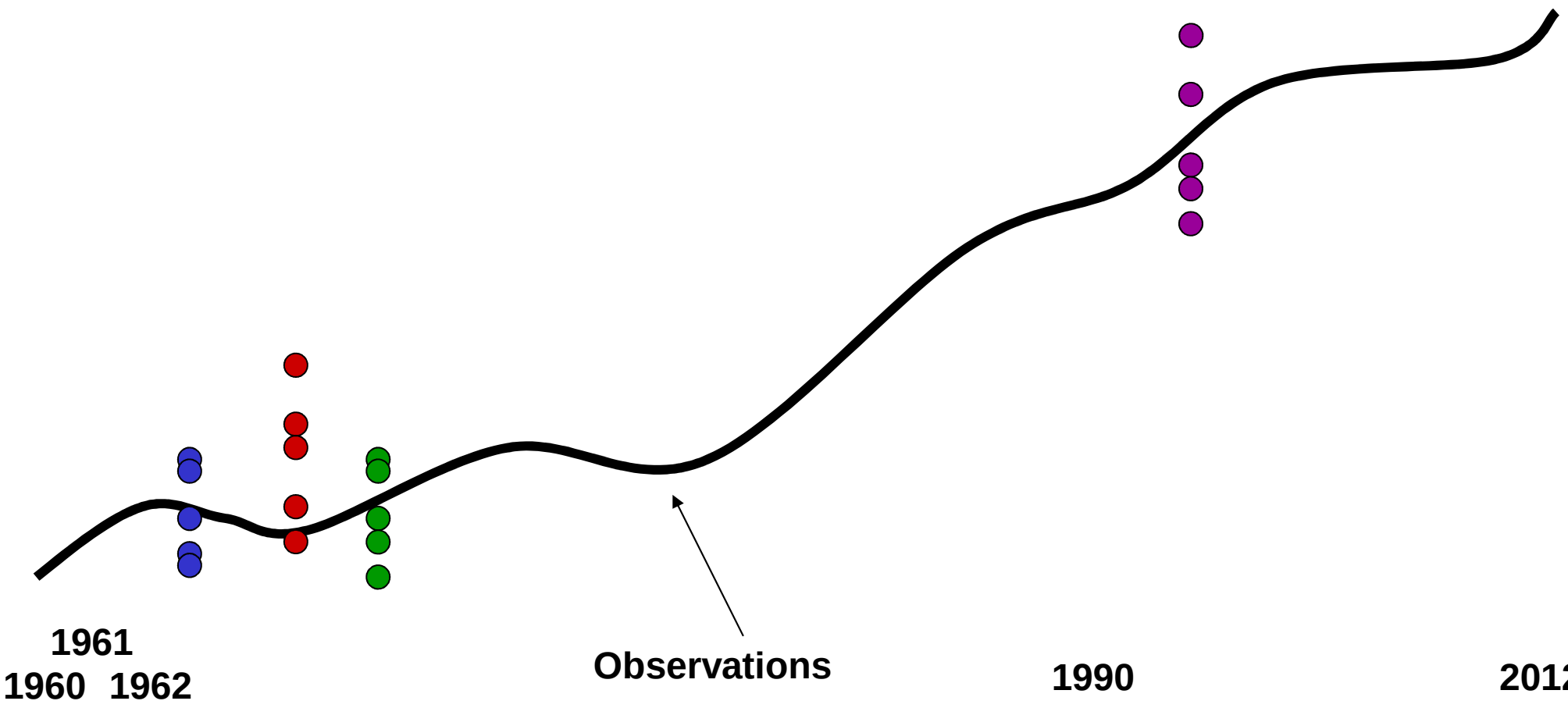
Example : Focus on 3rd forecast year



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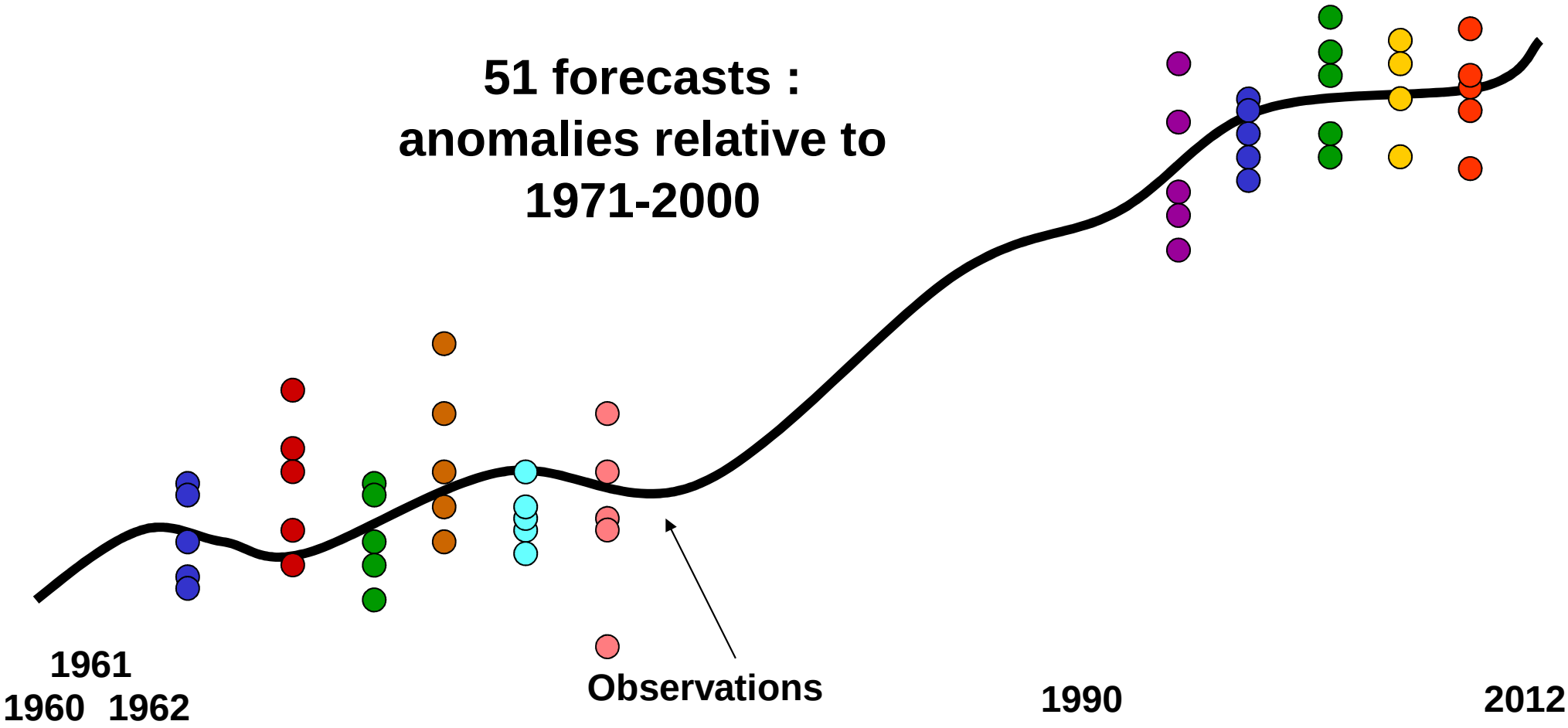
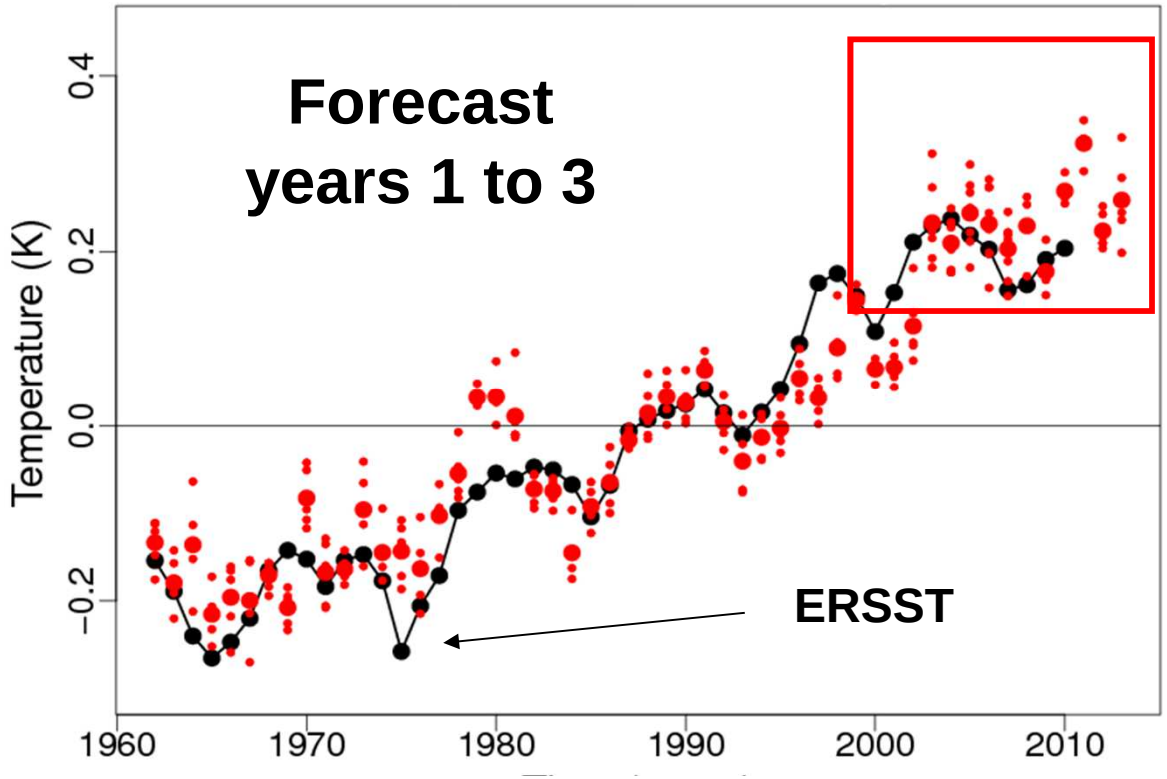
Analyses:

Example : Focus on 3rd forecast year



Successful climate prediction of the 2000-2010 global temperature plateau

Global mean Sea Surface Temperature (60°S-60°N)



The climate predictions capture the warming slowdown

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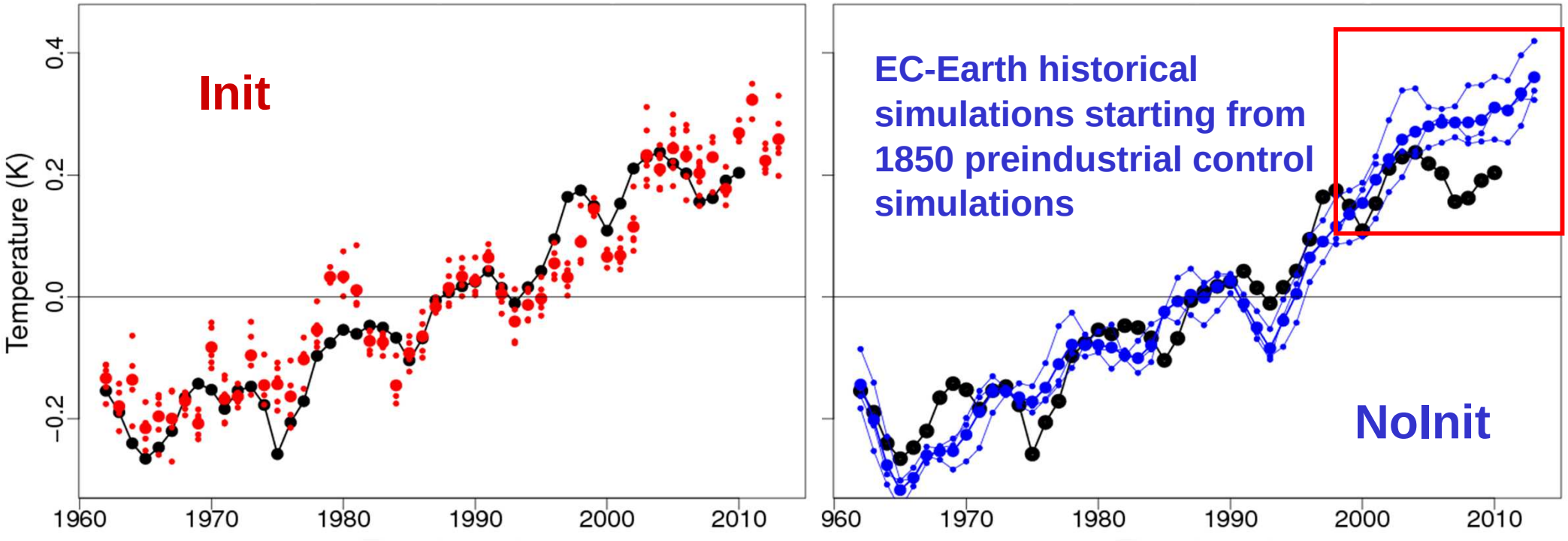
Successful climate prediction of the 2000-2010 global temperature plateau

Global mean Sea Surface Temperature (60°S-60°N)

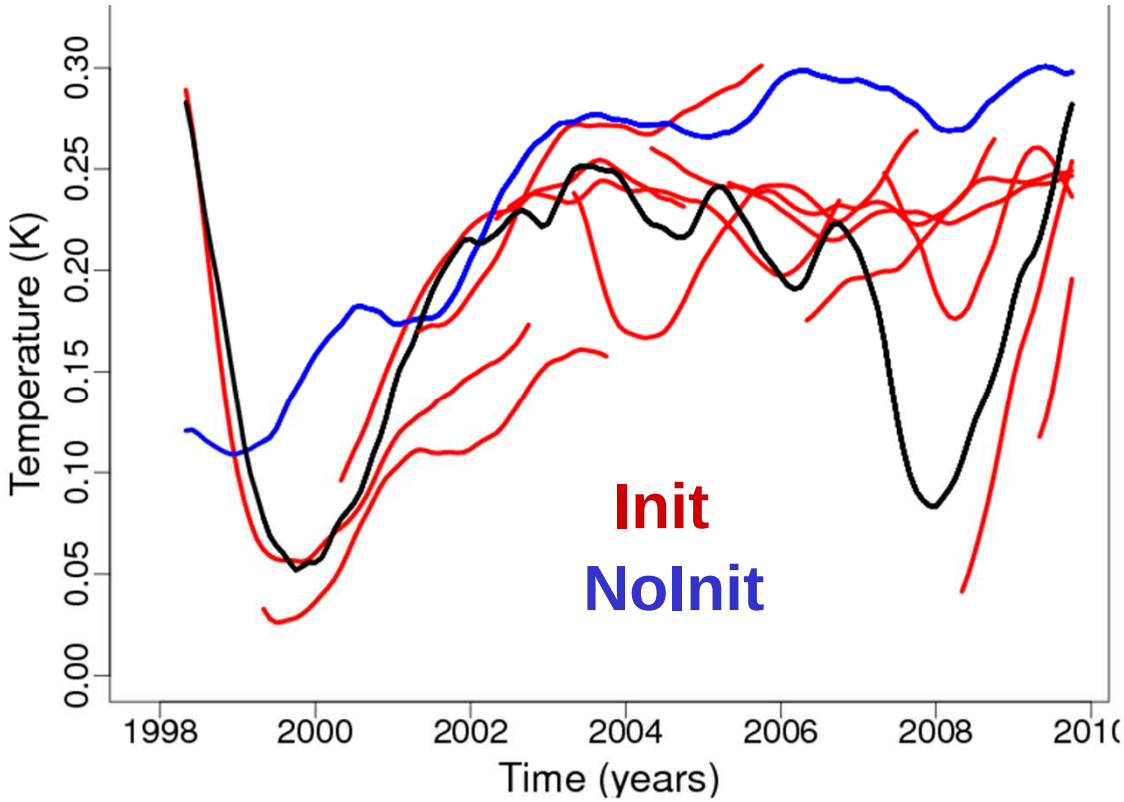


Initializing from observations is crucial to capture the plateau

Successful climate prediction of the 2000-2010 global temperature plateau

Global mean Sea Surface Temperature (60°S-60°N)

Smoothing with 1-year running mean



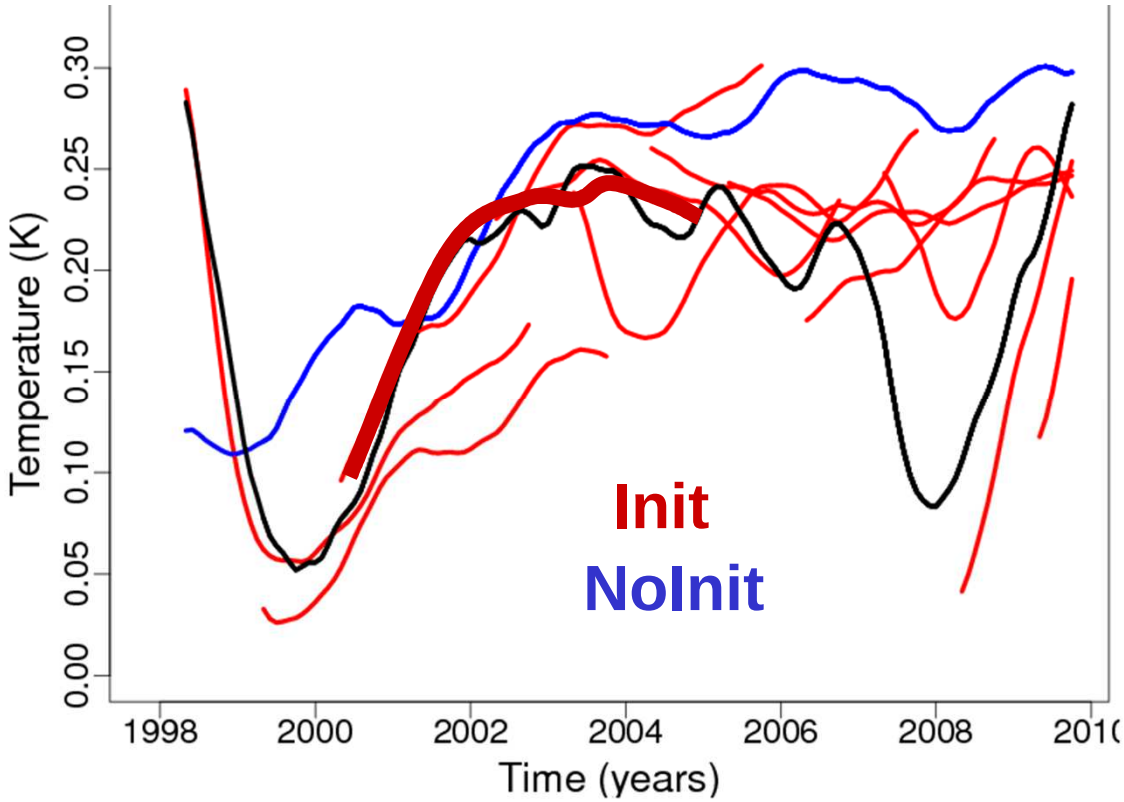
ERSST

Initializing allows to the SST evolution along the predictions

Successful climate prediction of the 2000-2010 global temperature plateau

Global mean Sea Surface Temperature (60°S-60°N)

Smoothing with 1-year running mean

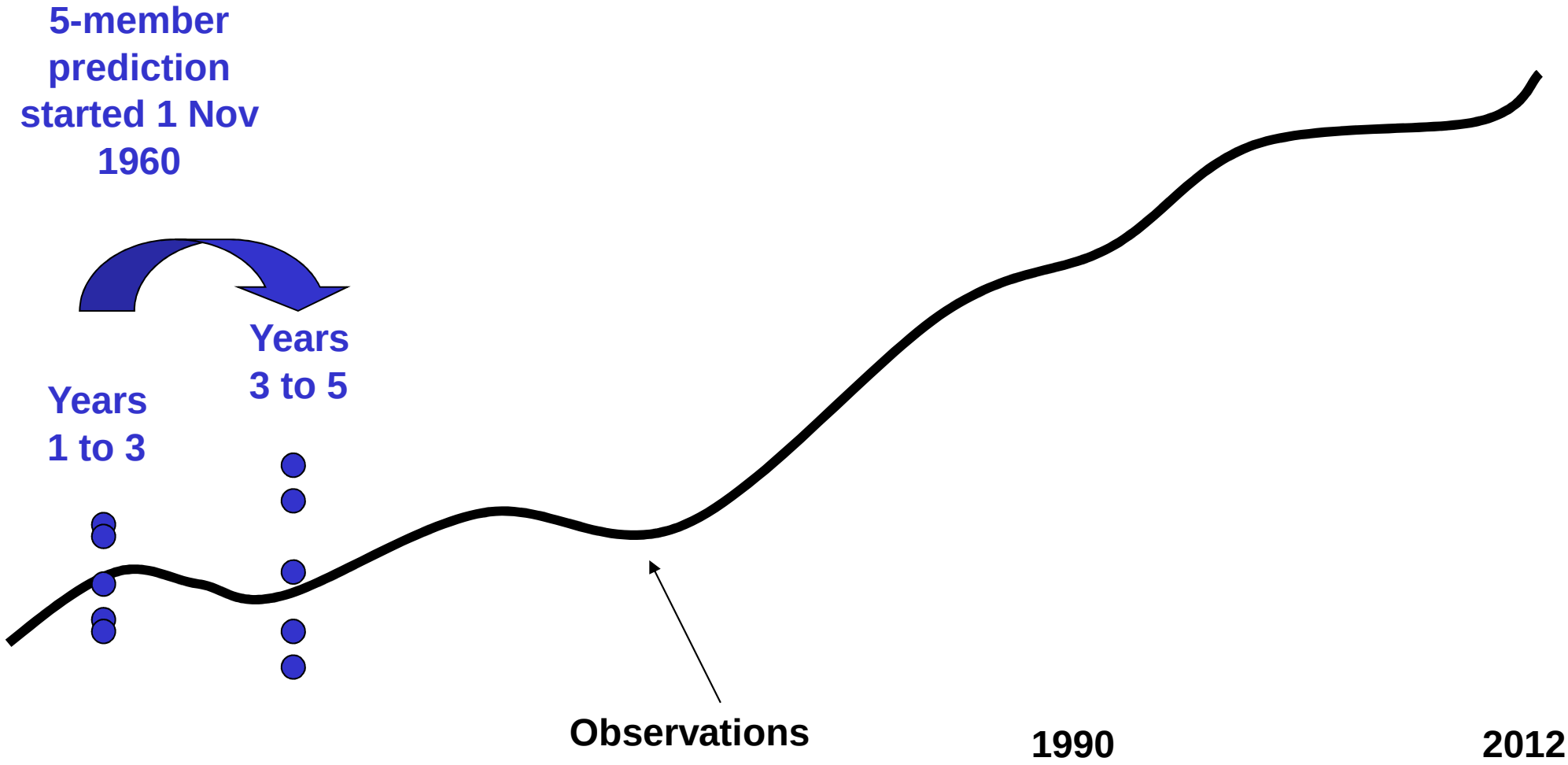


ERSST

Initializing allows to the SST evolution along the predictions

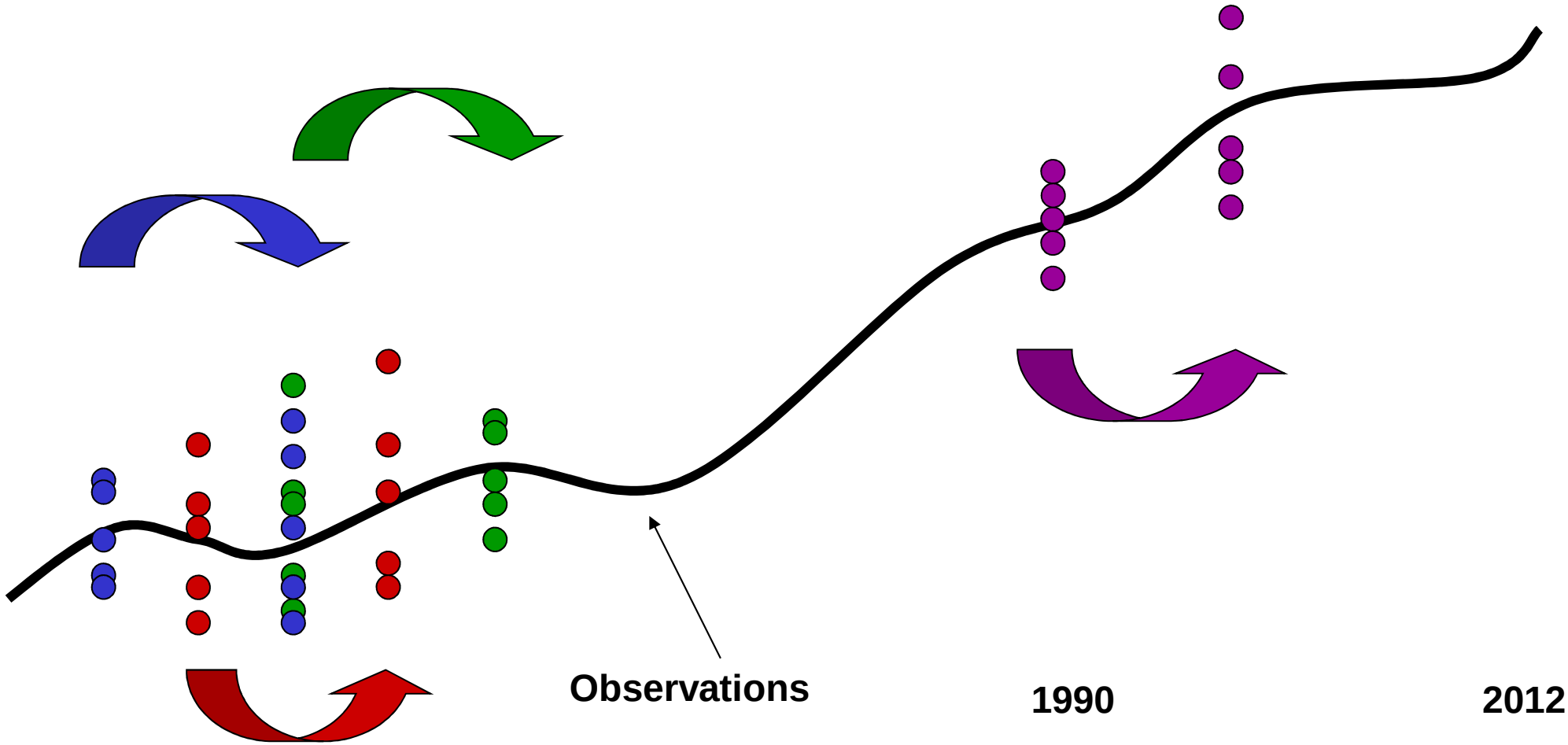
Methodology

Analyses: **3-year mean changes along the forecast**



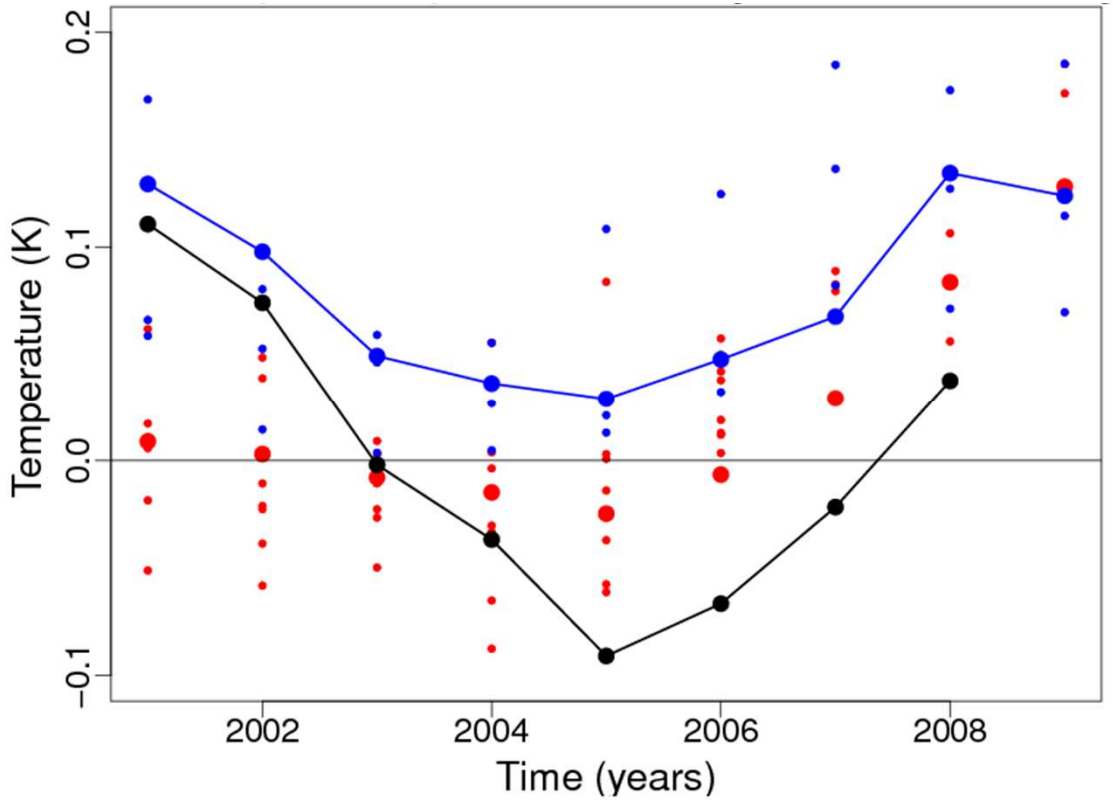
Methodology

Analyses: **3-year mean changes along the forecast**



Successful climate prediction of the 2000-2010 global temperature plateau

3-year mean change in global SST (60°S-60°N)



Init

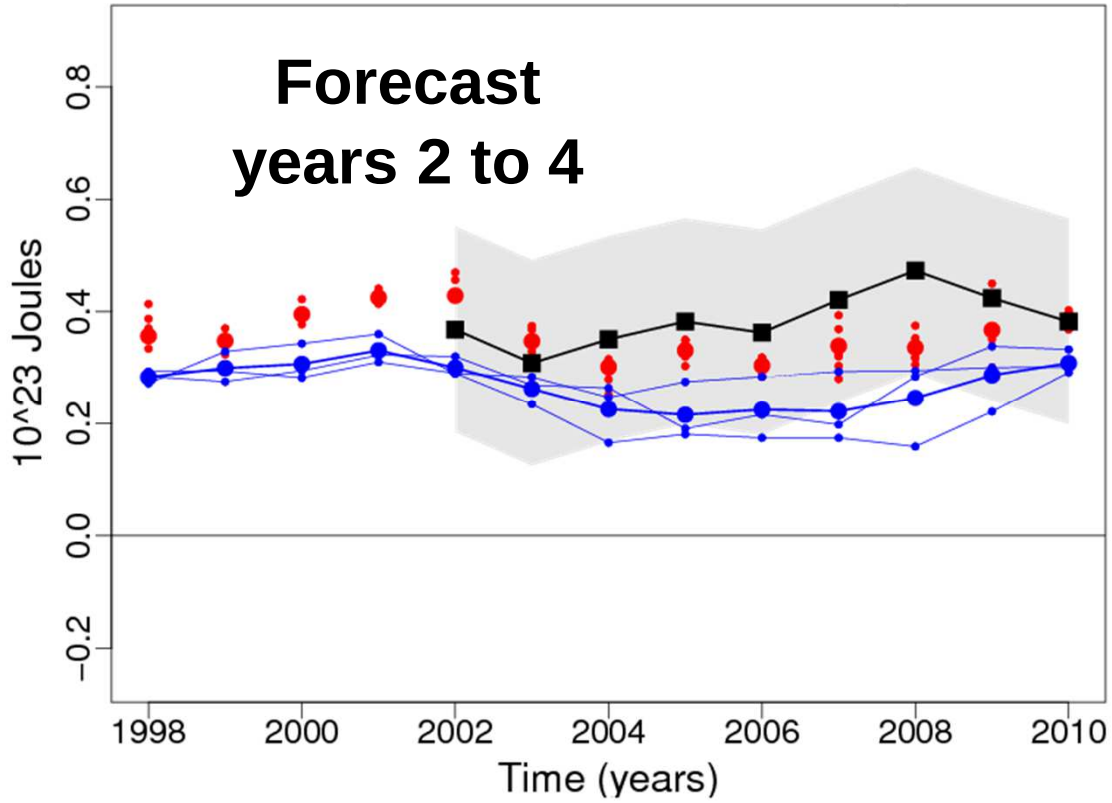
ERSST

NoInit

Initialization improves the SST trend along the forecast

Heat budget on those climate predictions to attribute the 2000-2010 global temperature plateau

Global Top-of Atmosphere Excess Energy



Init

CERES

NoInit

TOA input energy around 0.4 x 10^{23} Joules captured

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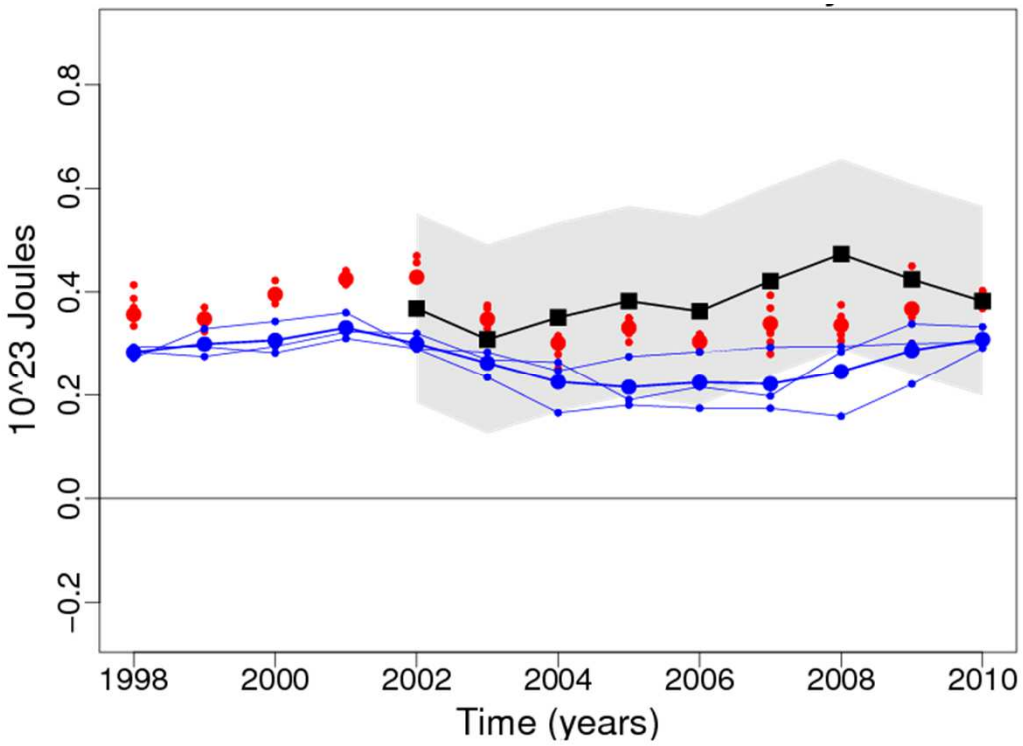
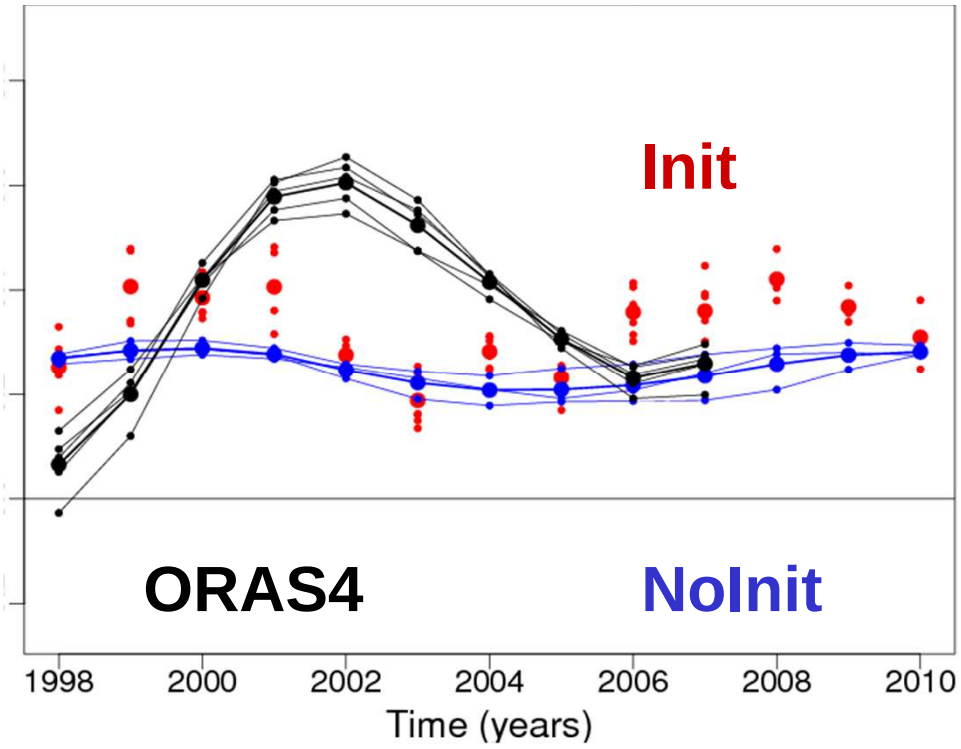
Heat budget on those climate predictions to attribute the 2000-2010 global temperature plateau

Global TOA Excess Energy



Global Ocean Heat Uptake



Increased Ocean Heat Uptake compensates for TOA inflow

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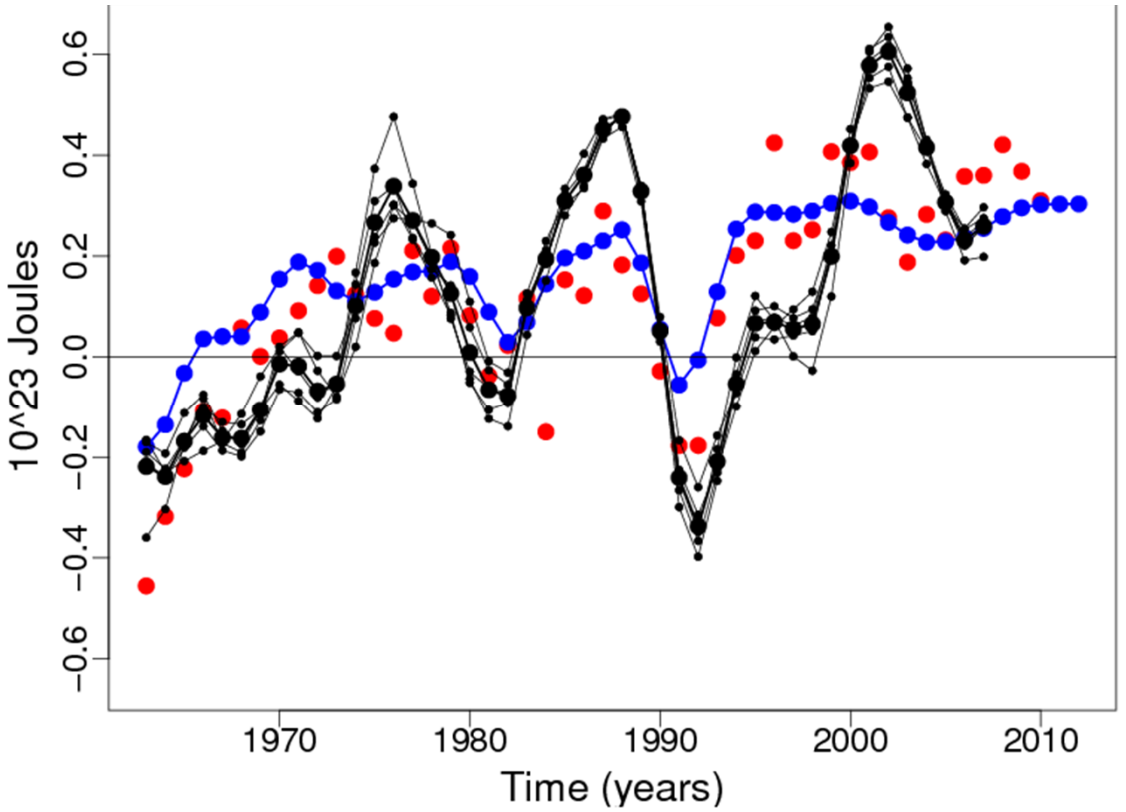
Heat budget on those climate predictions to attribute the 2000-2010 global temperature plateau

Global Ocean Heat Uptake



Init

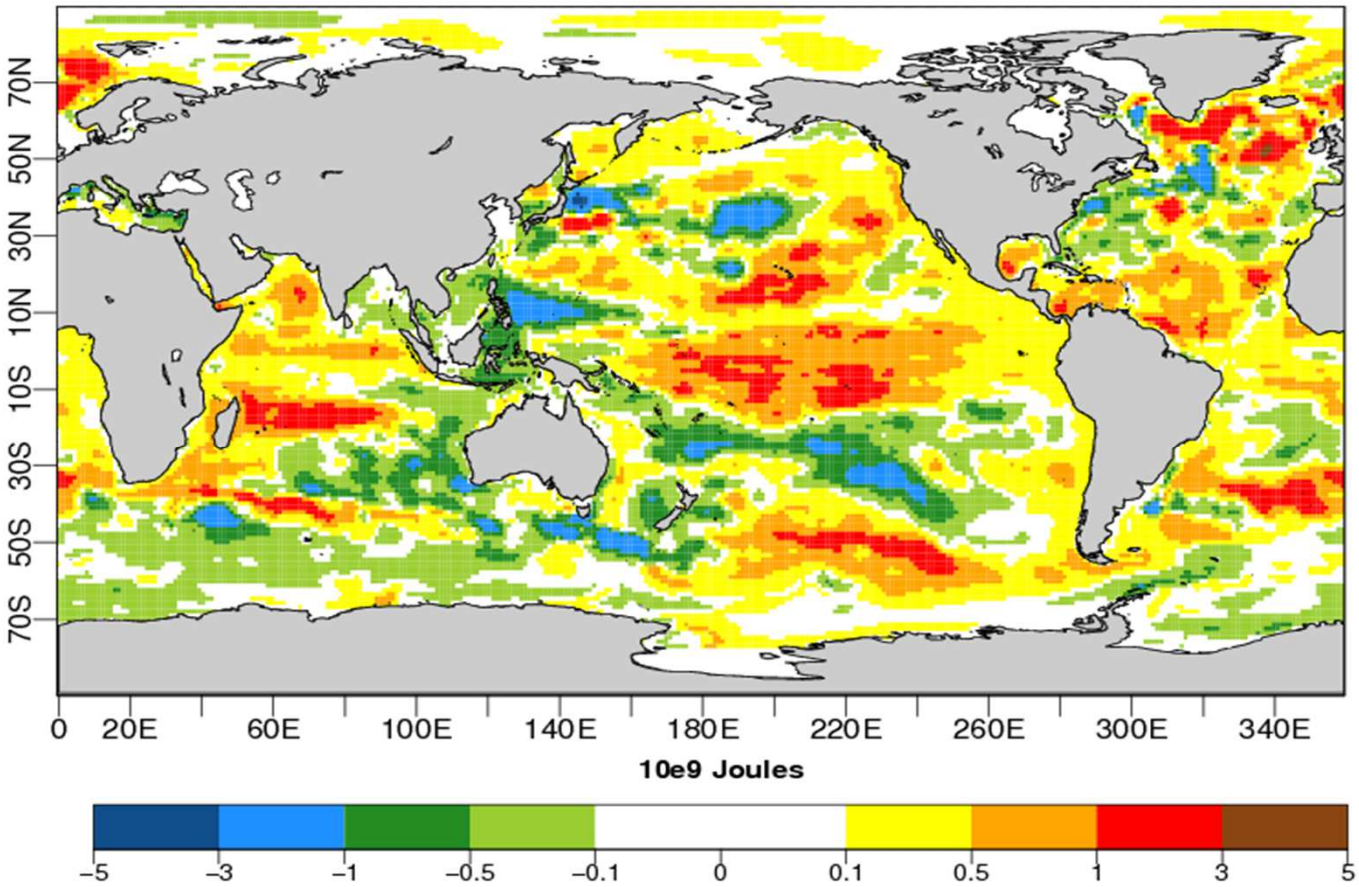
ORAS4

NoInit

Largest ever recorded peak in ocean heat uptake

Analysis of these predictions to attribute the 2000-2010 global temperature plateau

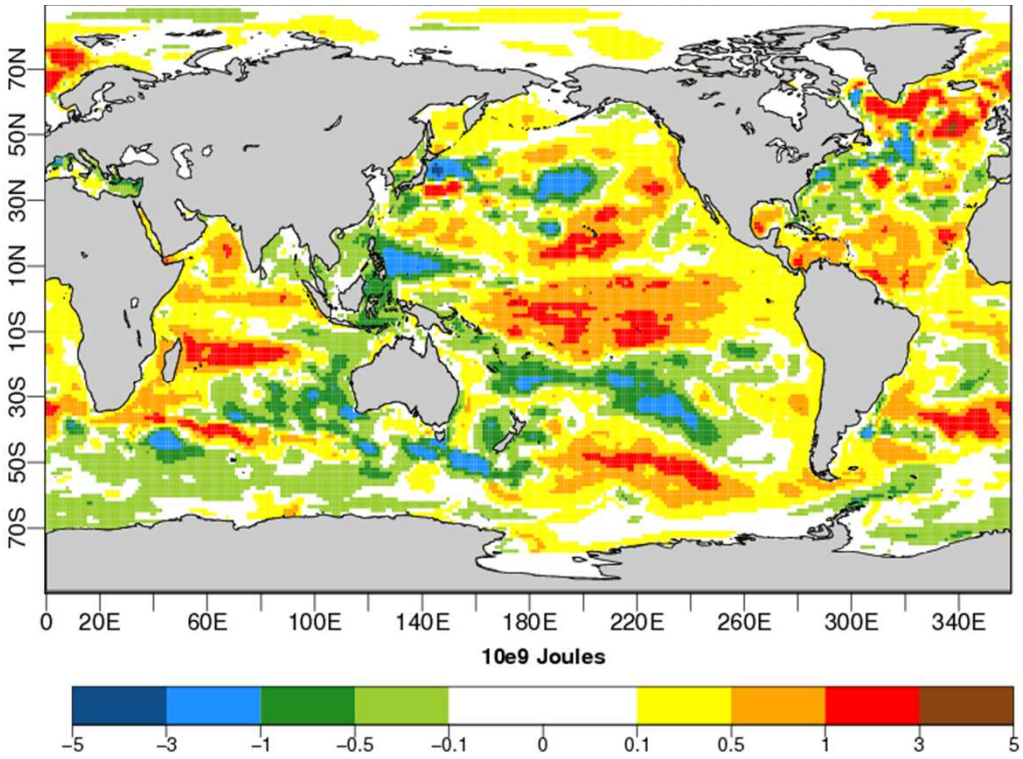
ORAS4 Ocean heat uptake (0-800m excluding the mixed layer) at the onset of the plateau



The plateau seems due to increased ocean heat absorption

Analysis of these predictions to attribute the 2000-2010 global temperature plateau

ORAS4



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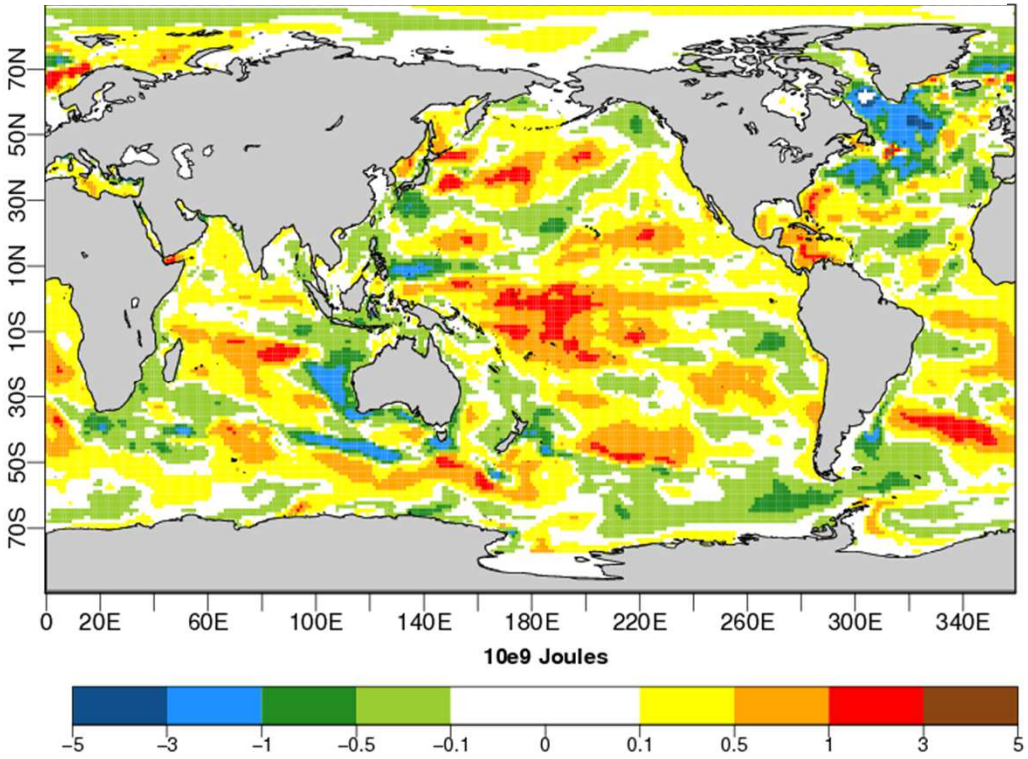
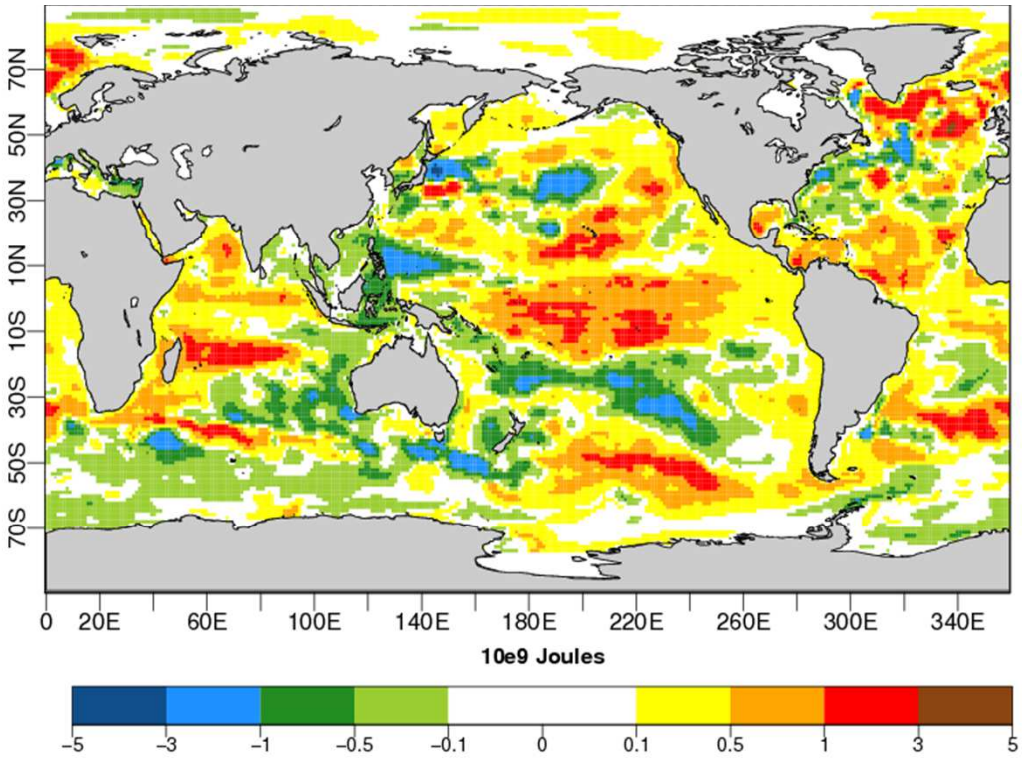


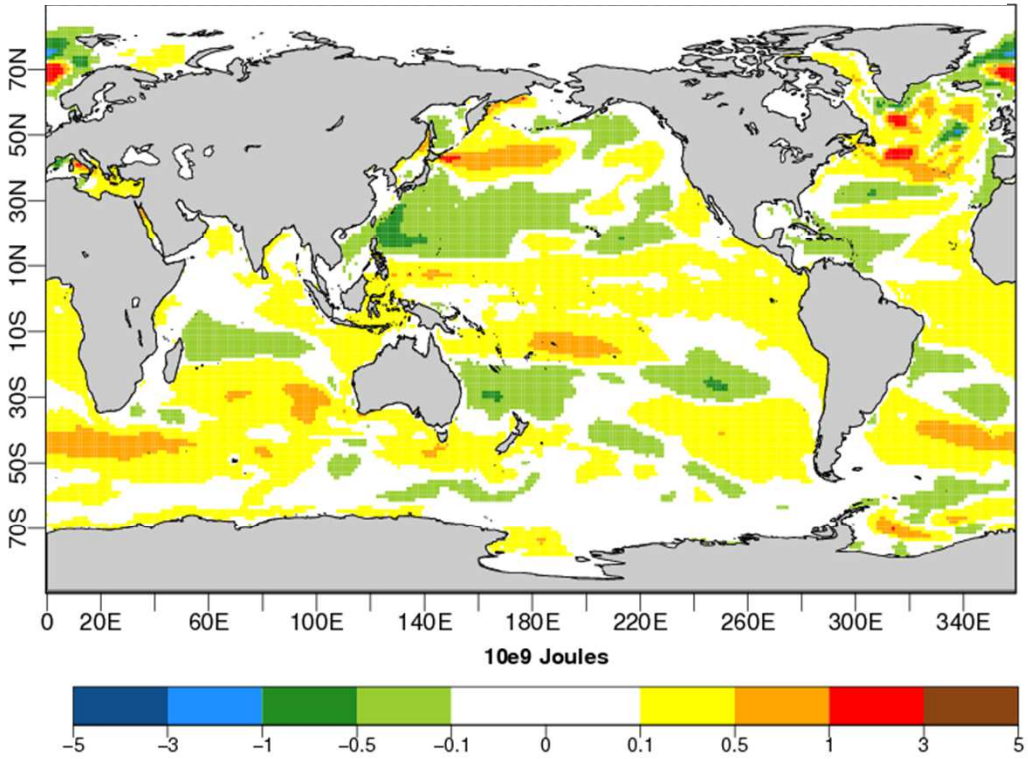
Increased ocean heat uptake in the Pacific captured by Init

Analysis of these predictions to attribute the 2000-2010 global temperature plateau

ORAS4



NoInit



Weak signals after ensemble-mean operator on NoInit

Summary of the results

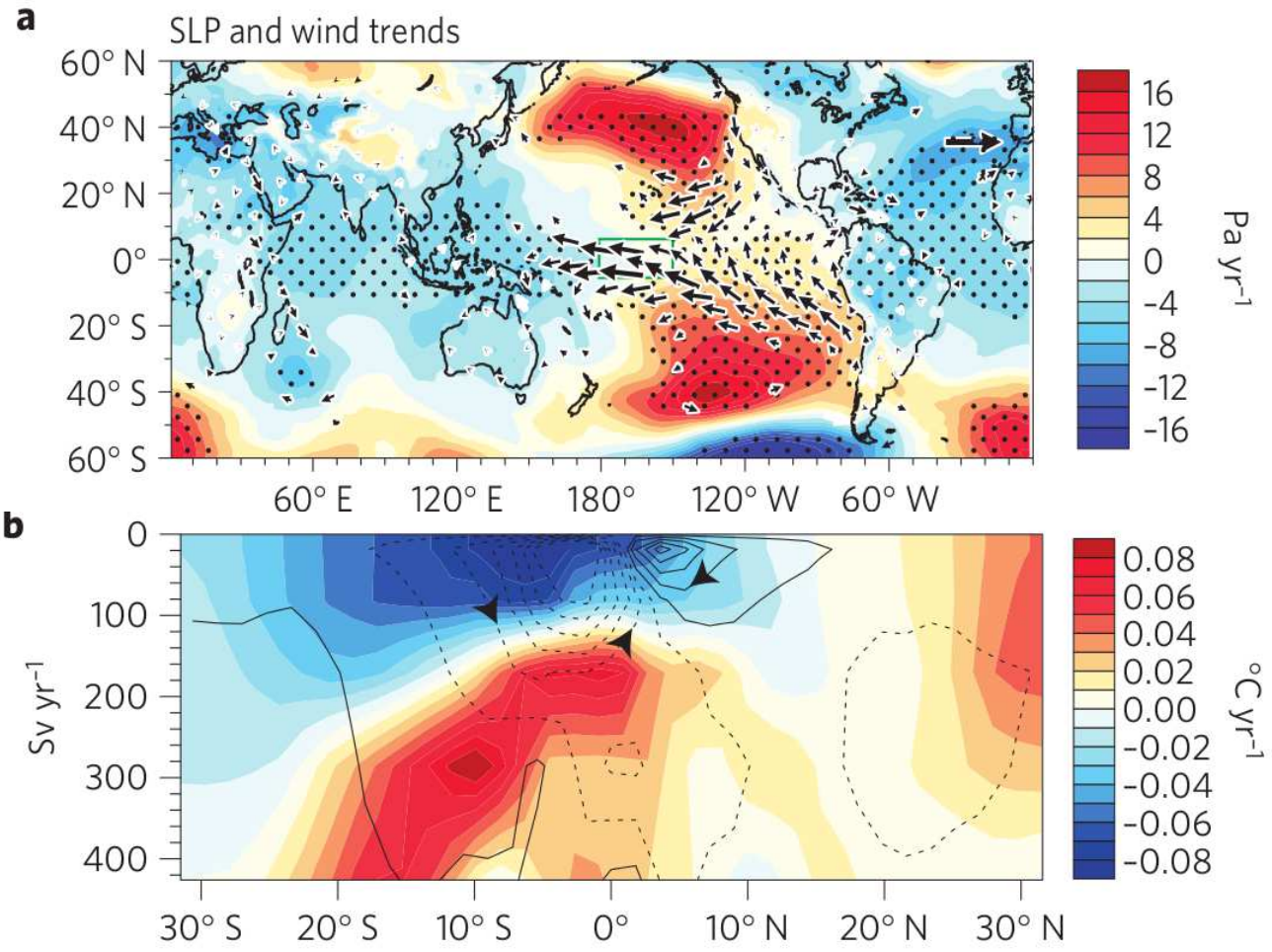
- **Ec-Earth climate predictions capture the temperature plateau until 5 years ahead. The realism of the SST trend along the forecast is improved with initialization.**
- **The Earth's heat budget shows that the TOA excess energy has been mainly absorbed in the ocean below the mixed layer at the onset of the plateau.**

Guemas V. , Doblas-Reyes F. J., Andreu-Burillo I., Asif M., 2013, Retrospective prediction of the global warming slowdown in the past decade. *Nature Climate Change*, doi : 10.1038/nclimate1863.

E : Increased ocean heat uptake

Observations

Model Response



Increased Pacific subsurface ocean heat uptake caused by strengthening of equatorial winds

England et al, 2014, Nature Climate Change

Conclusion : Back to the hypotheses

A - a decrease in the stratospheric water vapour concentration (Solomon, 2010)

B - an increase in the background stratospheric aerosol concentration (Solomon, 2013; Fyfe et al, 2013)

C - the deep and long solar minimum (Kaufmann et al., 2011; Hansen et al., 2011)

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Thank you very much for your attention

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